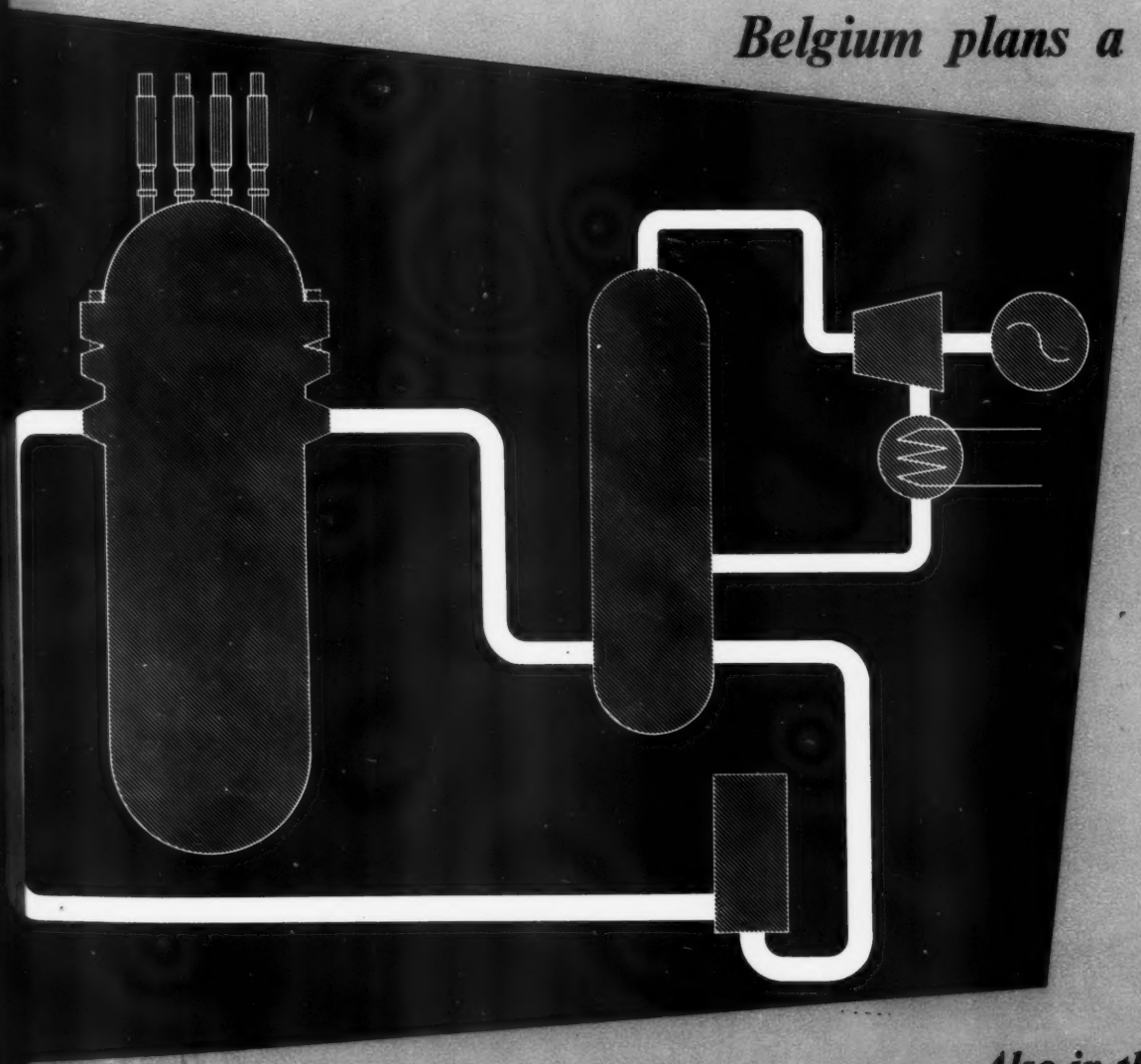
A ROWSE MUIR PUBLICATION

Nuclear Power

REACTORS · MATERIALS · INSTRUMENTATION · PROCESSES · RADIATION

DARTMOUTH COLLEGE
APR 1 3 1959
LIBRARY

Belgium plans a PWR



Also in this issue :

Fuel element design trends

Gas filtration problems

Efficiency of radiation detectors

April 1959 3/6

Tick **No 1** on reply card for further details

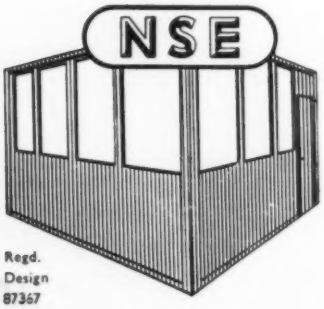
FACTORY
EQUIPMENT
EXHIBITION
EARLS COURT
APRIL 7—17, 1959
SEE OUR EXHIBIT

STAND E30

A matter of simple division?

No, Professor! Dividing floor space can be really difficult. You've got to make sure each square foot is used to the most efficient advantage. And what about changes? Expansion? New layouts?

Elementary, when you divide with NSE—the non-vibrating steel and glass partitioning that looks permanent but can be altered in no time to make offices, passages and bays of different sizes. It is inexpensive—*even cheaper than wood!*



Regd.
Design
87367

NORWOOD STEEL EQUIPMENT LTD

Makers of steel partitioning, steel plenum lockers etc.

Please write to Dept. H.H. for free illustrated brochures:
"STEEL PARTITIONING", "STEEL OFFICE FURNITURE and LOCKERS"
or "STEEL STORAGE EQUIPMENT"

149 Borough High Street, London, S.E.1
HOP 5033
and at Manchester, Birmingham and Bristol

Nuclear Power

REACTORS . MATERIALS INSTRUMENTATION . PROCESSES RADIATION

VOL 4 NO 36 APRIL 1959

MANAGING DIRECTOR A. H. David Rowse, MA

EDITORIAL

EDITOR Caldwell Davidson, MSC(ENG), DIC
DEPUTY EDITOR John Woodeson, BSC(ENG)
FEATURES EDITOR Patricia May, BSC
NEWS EDITOR Charles E. Steiner
EDITORIAL ASSISTANT Angela Funnell
PRODUCTION MANAGER Gerald Vane, BA (CANTAB)
PRODUCTION ASSISTANT Gerald Withers
CIRCULATION MANAGER Lionel A. Phillips
CIRCULATION ASSISTANT E. A. Hutcheson

CONSULTANTS

INSTRUMENTATION Denis Taylor, PHD, MIEE, FIP
PHYSICS James F. Hill, BSC
METALLURGY Prof J. G. Ball, BSC, FIM
ISOTOPES A. G. Maddock, MA, PHD, DIC

ADVERTISEMENTS

DIRECTOR Harry T. Kane
ADVERTISEMENT MANAGER John Abram
SOUTHERN REPRESENTATIVE K. M. Towell
BIRMINGHAM OFFICE Trevor N. Bertram
MANCHESTER OFFICE Barry Gibbs
NEWCASTLE OFFICE Peter Doig
CLASSIFIED ADVERTISEMENTS John Deamer

U.S. REPRESENTATIVE

Walter J. Masterson, Jr
Box 206, Essex, Conn. *tel:* South 7-1838

NUCLEAR POWER is published by Rowse Muir Publications Ltd, 3 Percy Street, London, W1, England, and printed by The Haycock Press Ltd, SE5. The entire contents are protected by copyright in Great Britain and all the countries signatory to the Bern Convention; nothing therefrom may be reproduced in any manner without the written permission of Rowse Muir Publications Limited. Nuclear Power must not, without the consent—in writing—from the publishers, be re-sold, lent, hired out or otherwise disposed of in a mutilated condition or in any unauthorized cover, by way of trade, or annexed to or as part of any other publication or advertising, literary or pictorial matter whatsoever. Special attention is called to the fact that your acceptance of this magazine with notice of the above terms constitutes a contract upon these terms between you and the person who sold it or supplied it. Subscriptions to publishers Rowse Muir Publications Ltd. Single copies UK 3/6, 5/6 overseas, 75c US and Canada. Per annum £2.2.0 UK, £3.3.0 overseas, $8.0 US and Canada plus 50s postage.

SPECIAL FEATURES

Belgium plans its own PWR
In the first authoritative account to reach Britain, Charles Gérard of ACEC reveals their proposed design for a 145MW plant 86

Trends in fuel element design
The first international symposium on this important nuclear topic was held recently at Columbia University and is reported here by the only British delegate, Dr G. B. Greenough of Windscale 92

Efficiency of nuclear radiation detectors
Continuing our new series on detection methods, W. R. Loosemore, Harwell, discusses the efficiency of the instruments used for the various types of radiation 97

Dragon—joint project for HTGR development
Plans to build a high temperature 10MW plant at Winfrith Heath were announced by the OEEC in February 102

Dust removal in gas-cooled reactors
R. A. Le Page, managing director of Mancuna Engineering Ltd, describes one approach to the problem of high efficiency CO_2 filtration 104

NUCLEAR TECHNOLOGY

REACTORS:
Single-zone U-233/thoria reactors *by W. G. Clarke* 109

PROCESSES:
Activity build-up in PWRs using stainless steel *by Walter H. Zinn* 109

INSTRUMENTATION:
An all-steel gas proportional counter *by Denis Aliaga-Kelly* 111

MATERIALS:
An improved pvc plasticizer *by the Geigy Company Ltd* 112

PROGRESS IN INDUSTRY

Complete bellows service now available
Teddington Aircraft aims to meet all nuclear needs 113

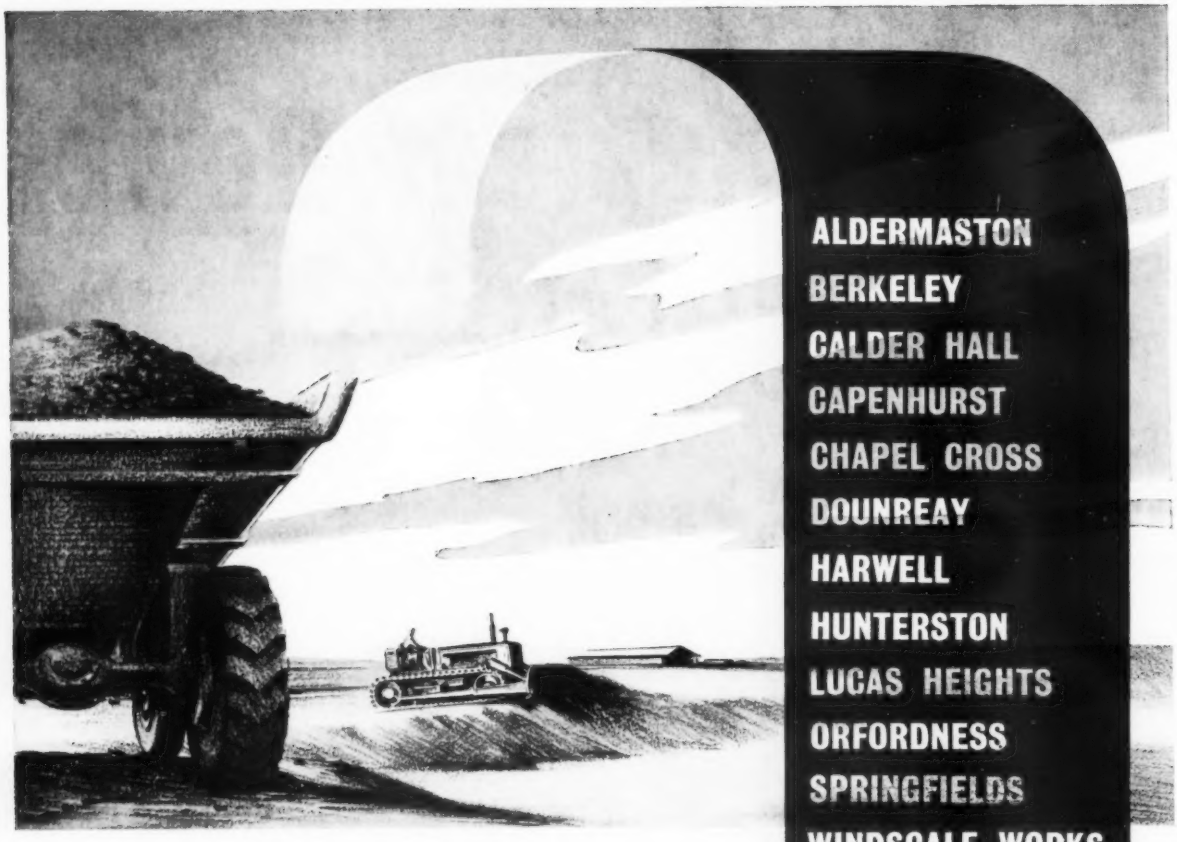
Self-sealing couplings for liquids and gases
Transfer systems by Lockheed Precision 114

REGULAR FEATURES

Publisher's Column	73	Names in the News	124
Letters	75	Points from Papers	126
Leader	77	Catalogues and Bulletins	128
Worldview	81	Diary	128
Cross-Section *Gracchus*	108	Book Reviews	130
New Product Survey	116	Classified Advertisements	158
Industrial Newsdesk	119	Advertisers in this issue	160

RM

ROWSE MUIR PUBLICATIONS LTD, 3 PERCY STREET, LONDON, W1, ENGLAND tel: Museum 8252



ALDERMASTON
BERKELEY
CALDER HALL
CAPENHURST
CHAPEL CROSS
DOUNREAY
HARWELL
HUNTERSTON
LUCAS HEIGHTS
ORFORDNESS
SPRINGFIELDS
WINDSCALE WORKS
WINFRITH HEATH

Once upon a time ...

these names now synonymous with atomic development were places of dreams, plans, research in minds of men.

Every aspect was considered in the project, and interwoven with this pattern the name of Wharton appeared when crane facilities were required. Wharton technical staff aided design, provided advice and met the individual problems of each station. In every way the Wharton Crane & Hoist Company link their name with those which will long be recorded in the lists of achievement.

THE WHARTON CRANE & HOIST CO. LTD.

REDDISH STOCKPORT ENGLAND

Phone : Heaton Moor 2227. Grams : "Gallant, Manchester." Code : Western Union.

LONDON: Lincoln House, 296-302 High Holborn W.C.1.	Phone: Chancery 7911.	Grams: Chancery 7911.
SCOTLAND and NORTHERN COUNTIES: Fisher-Baxter & Co., 140 West George Street, Glasgow C.2.	Phone: Douglas 1061-2-3.	Grams: Fluorspar, Glasgow.
MIDLANDS: A. R. Holland & Son, 89 Cornwall Street, Birmingham 3.	Phone: Central 1457.	Grams: Central 1457, Birmingham.
SOUTH-WEST: R. C. Collins, 48 Westbourne Road, Penarth, Glamorgan.	Phone: Penarth 58527.	Grams: Penarth 58527.
NORTHERN IRELAND: General Engineering Products Ltd., 7-9 Great Patrick Street, Belfast.	Phone: Belfast 23743.	Grams: Belfast 23743.
REPUBLIC of IRELAND: Charles Nolan & Co., 2 Parker Hill, Lower Rathmines Road, Dublin.	Phone: Dublin 93510.	Grams: Dublin 93510.
CANADA: Marshall Equipment Co. Inc., P.O. Box 28, 61 O'Connell Avenue, Dorval Station, P.Q.	Phone: Melrose 1-3528.	Grams: Marquipco, Montreal.
SOUTH AFRICA: Kenneth Ray Ltd., P.O. Box 5662, 34 Ameshoff Street, Braamfontein, Johannesburg.	Phone: 44-2168.	Grams: Gemray.

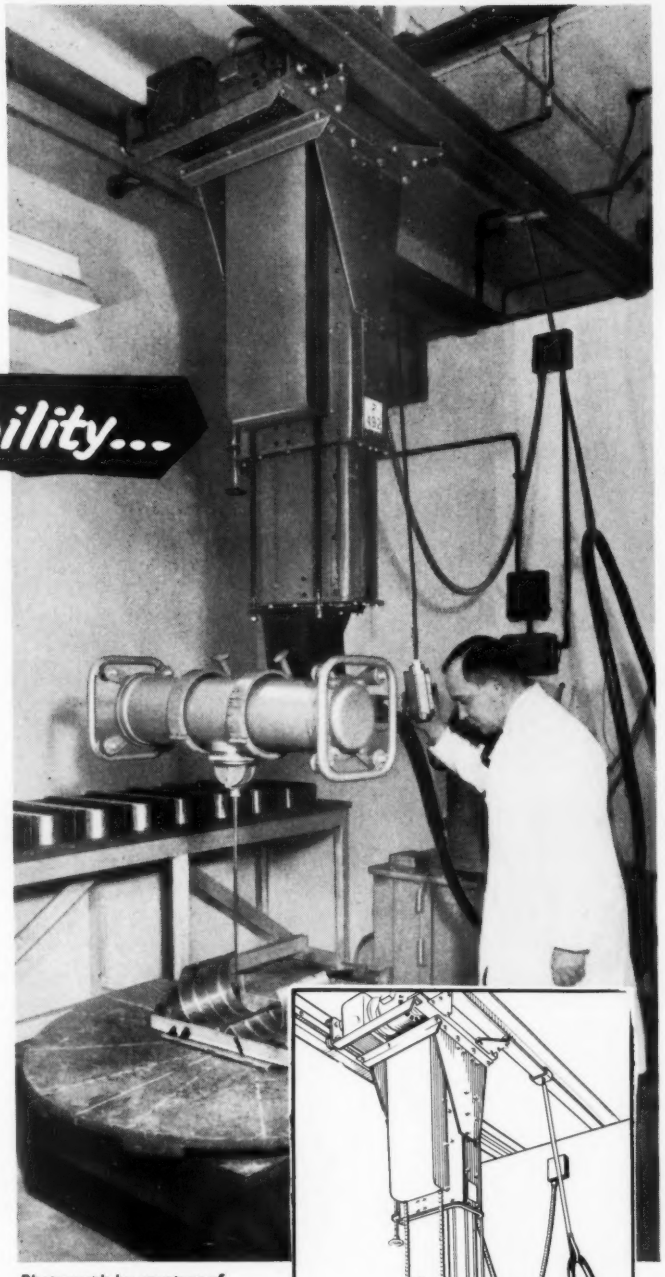
REPRESENTED IN PRINCIPAL COUNTRIES THROUGHOUT THE WORLD

Speed and Flexibility...

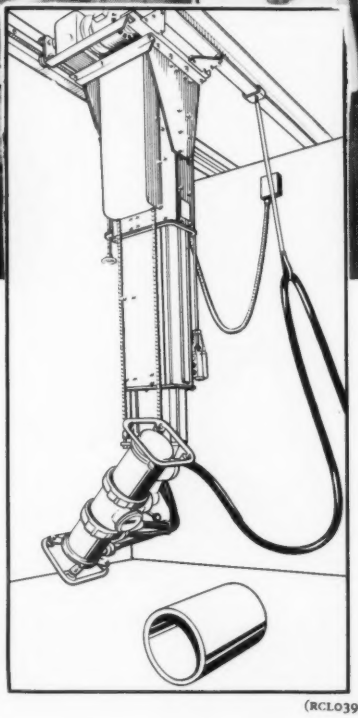
A motorised and telescopic mounting by PHILIPS and a 300 kV dual-focus X-ray unit by MÜLLER*

All the benefits of unimpeded floor space and the ability to deal with specimens of the widest variety of shapes and sizes are *yours* with this new motorised overhead suspension gear by PHILIPS. And always with the minimum of time and effort. This equipment has been so designed as to be easily adaptable to any particular site condition. Catering for the examination of longitudinal seams for instance, offers no problem. The amount of traverse can be 'tailored' to suit the room, and can be arranged in both directions. For use with an existing unit the overhead suspension gear can be supplied separately.

*C. H. F. Müller, Hamburg.



Photograph by courtesy of Palmer X-ray, London.



Right: Fully extended, focus/floor distance 18". At maximum height: focus/floor distance 5' 6".

Other vertical limits can be catered for.

(RCL0394A)

THIS VERSATILE EQUIPMENT MAY SOLVE YOUR PROBLEM

Write to-day for further information. Without obligation we will gladly submit a proposal.

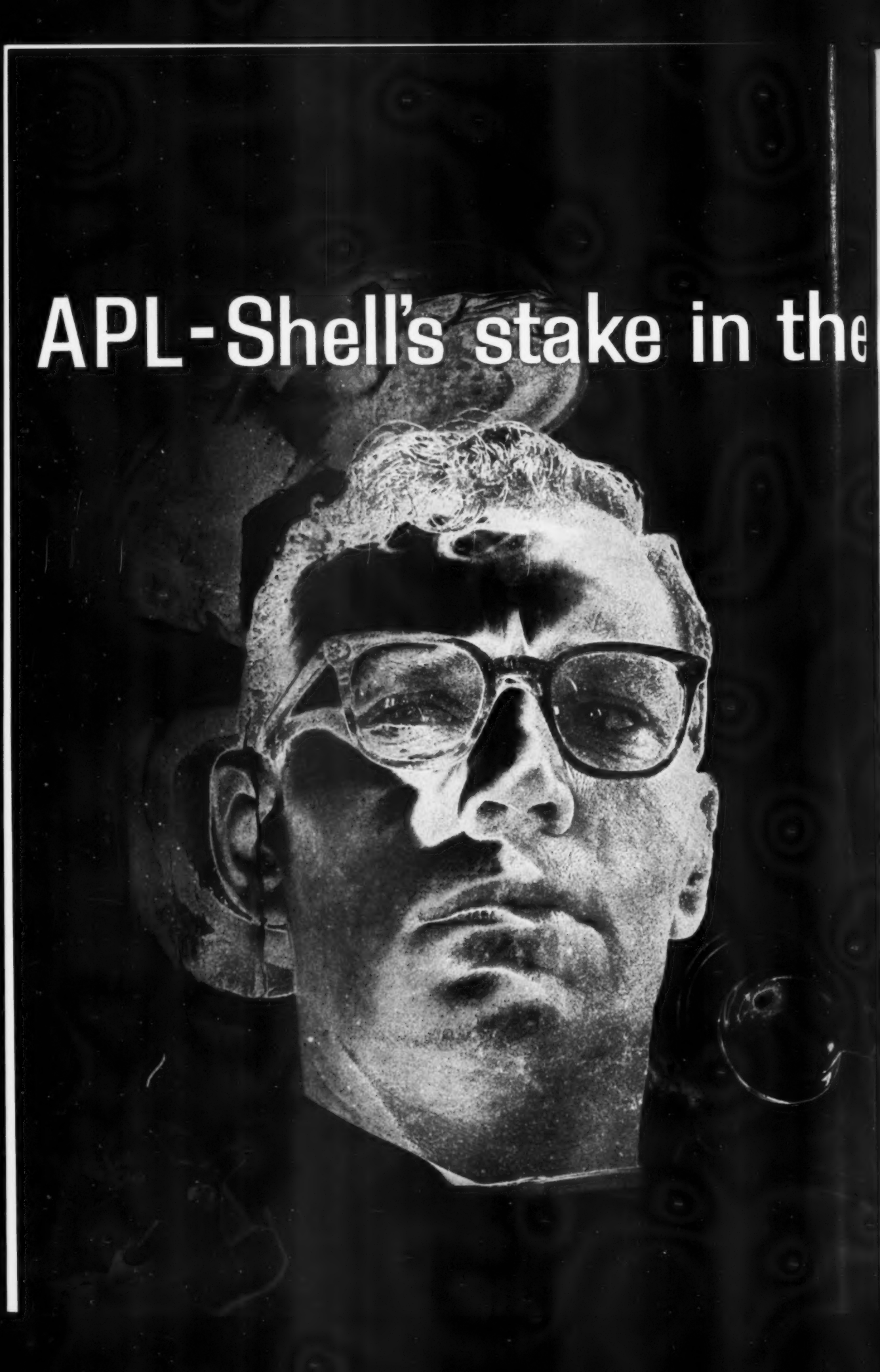
Sole distributors in the U.K.:

RESEARCH & CONTROL INSTRUMENTS LTD.

INSTRUMENT HOUSE, 207 KING'S CROSS ROAD, WC1

Telephone: Terminus 8444

APL-Shell's stake in the



first nuclear decade

To a world hungry for energy, nuclear power brings rich promise. With it, inescapably, come complex new problems which can be mastered only by imaginative thinking.

Conventional lubricants, for instance, are useless when exposed to radiation. They break down, thicken and form harsh solids. Yet the lubricants needed for mechanisms close to the reactor may have to withstand radiation 4 million times stronger than would kill a man. Some of them have to take such punishment continuously for two years or more, for the complicated mechanisms they lubricate cannot be serviced without closing down the reactor altogether – a costly business with plant involving a capital outlay of some £50,000,000.

In 1953, when it was realised that radiation-resistant lubricants were essential, Shell decided to start an extended programme of research. Special groups were set up at Shell's Thornton Research Centre, a generous budget allocated, and their own Cobalt 60 source of radiation installed. Repeated tests took place there and under actual reactor radiation at the United Kingdom Atomic Energy Research Establishment at Harwell.

In 1957 after four years of work the Shell group introduced the world's first range of Atomic Power Lubricants under the brand name of Shell APL – Shell's stake in the first nuclear decade.

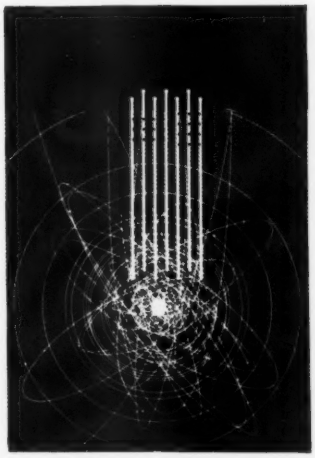
Today Shell APL is still the only range of proved radiation-resistant lubricants on the market. Oils and greases from this range, as well as other Shell Industrial Lubricants, are in daily use at many nuclear establishments in the United Kingdom and elsewhere – in lubricating control rod mechanisms, manipulators, electric motors, blower fans and steam turbines. They have also been chosen for the new British atomic power station under construction at Bradwell in Essex.

Here is Shell leadership in lubrication in action – anticipating a need, undertaking fundamental research, and finally developing the products to solve a problem of world-wide importance.

The Research Story

In the hundreds of complex hydrocarbons examined, very different reactions to radiation were observed according to the configuration of the atoms in the molecules. Highly complex structures of an entirely different nature from the original material were formed. Following extensive experiments, the Shell APL range of lubricants was developed and proved. Included are such oils as Shell APL 729 mainly for use in blowers. This oil now has a performance equal to a good quality modern turbine oil. Shell APL 700 series greases have been tested in bearings operated within the BEPO reactor and subjected to CO_2 gas under pressure at 150°C. After receiving a total dosage of 2.7×10^{18} thermal neutrons plus associated radiation, the grease and bearings were found to be still in good condition.

Other lines of research include the latest developments in the use of radio-active isotopes in the measurement of wear. Recent results have been published in a paper presented at the 1958 Geneva Conference, a further example of the work continually being undertaken by the Shell group to assist industry.



SHELL

ATOMIC POWER LUBRICANTS

another proof of Shell leadership in lubrication

Tick **No 5** on reply card for further details

Getting in touch with

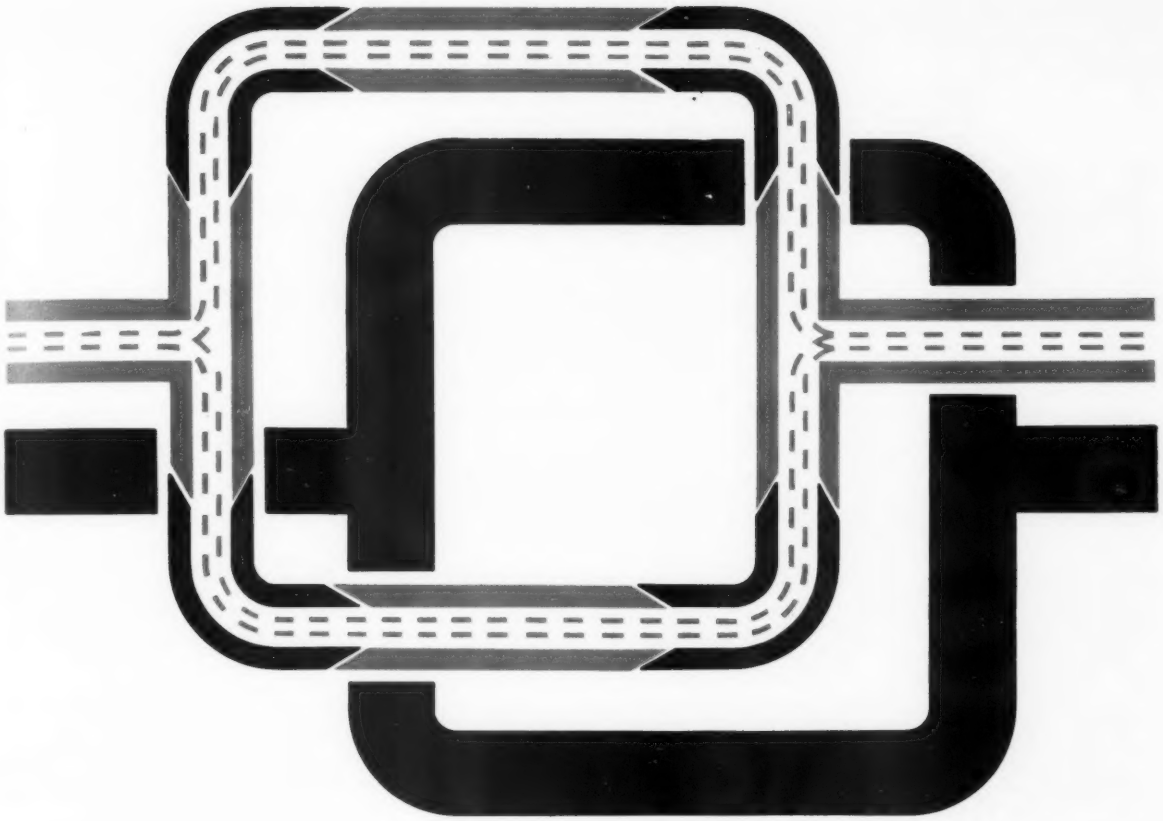
ASSOCIATED LEAD

usually leads to better things

No matter how you do it, no matter what your particular industrial need, getting in touch with Associated Lead is bound to lead to better things—better products, better processes—for you and your industry.
Associated Lead Manufacturers Limited is a single company specialising in the manufacture and supply of lead and antimony in all their many forms; alloys; pure metals; chemicals and pigments.

ASSOCIATED LEAD MANUFACTURERS LIMITED CLEMENTS HOUSE, 14 GRESHAM STREET, LONDON, E.C.2.
CRESCENT HOUSE, NEWCASTLE. LEAD WORKS LANE, CHESTER.

Export enquiries to: Associated Lead Manufacturers Export Co. Ltd., Clements House, 14 Gresham Street, London, E.C.2.



Your piping problems solved

A new type of piping which will carry corrosive liquids,
solvent vapours and the like, at elevated temperatures,
is now solving many maintenance problems and
thus reducing operating costs in chemical and other plants.
Made from 'Epikote' resins reinforced with glass fibre,
these pipes are as strong as drawn steel and much lighter.
They can be made to any desired shape or section:
tailored, in fact, to meet the most complex requirement.
Ask now for details of 'Epikote' resins
and their many structural uses. (Please quote No. EE.7)

EPIKOTE EPOXY RESINS

SHELL CHEMICAL COMPANY LIMITED

In association with Petrochemicals Limited and Styrene Products Limited

Divisional Offices: LONDON 105-9, Strand, W.C.2. Tel: Temple Bar 4455.
MANCHESTER 144-6, Deansgate 3. Tel: Deansgate 2411.
BIRMINGHAM 14-20, Corporation Street, 2. Tel: Midland 6954.
GLASGOW 124, St. Vincent Street, C.2. Tel: Central 9561.
BELFAST 16-20, Rosemary Street. Tel: Belfast 26094.
"EPIKOTE" *is a Registered Trade Mark.* DUBLIN 33-34, Westmoreland Street. Tel: Dublin 72114.

More than 80
SUNVIC STRIP CHART RECORDERS
will be used at Berkeley...

... for monitoring:

LINEAR POWER

BACKED-OFF LINEAR POWER

LOGARITHMIC POWER

LOW LOGARITHMIC POWER

LOW POWER COUNTER CHANNEL

FUEL ELEMENT CAN SURFACE TEMPERATURES

DUCT CO_2 TEMPERATURES

CHANNEL CO_2 TEMPERATURES

GRAPHITE TEMPERATURES

PRESSURE VESSEL AND DUCT TEMPERATURES

BIOLOGICAL SHIELD TEMPERATURES

FLUX DISTRIBUTION

CONTROL ROD POSITIONS

BURST CARTRIDGE ACTIVITY

SUMMATED GAS FLOW

WATER CONTENT OF CO_2

CO_2 CONTENT OF STEAM

PRESSURE VESSEL GAS PRESSURE

The flexibility of this recorder is such that all will be instruments with *standard* additional facilities. These include:-

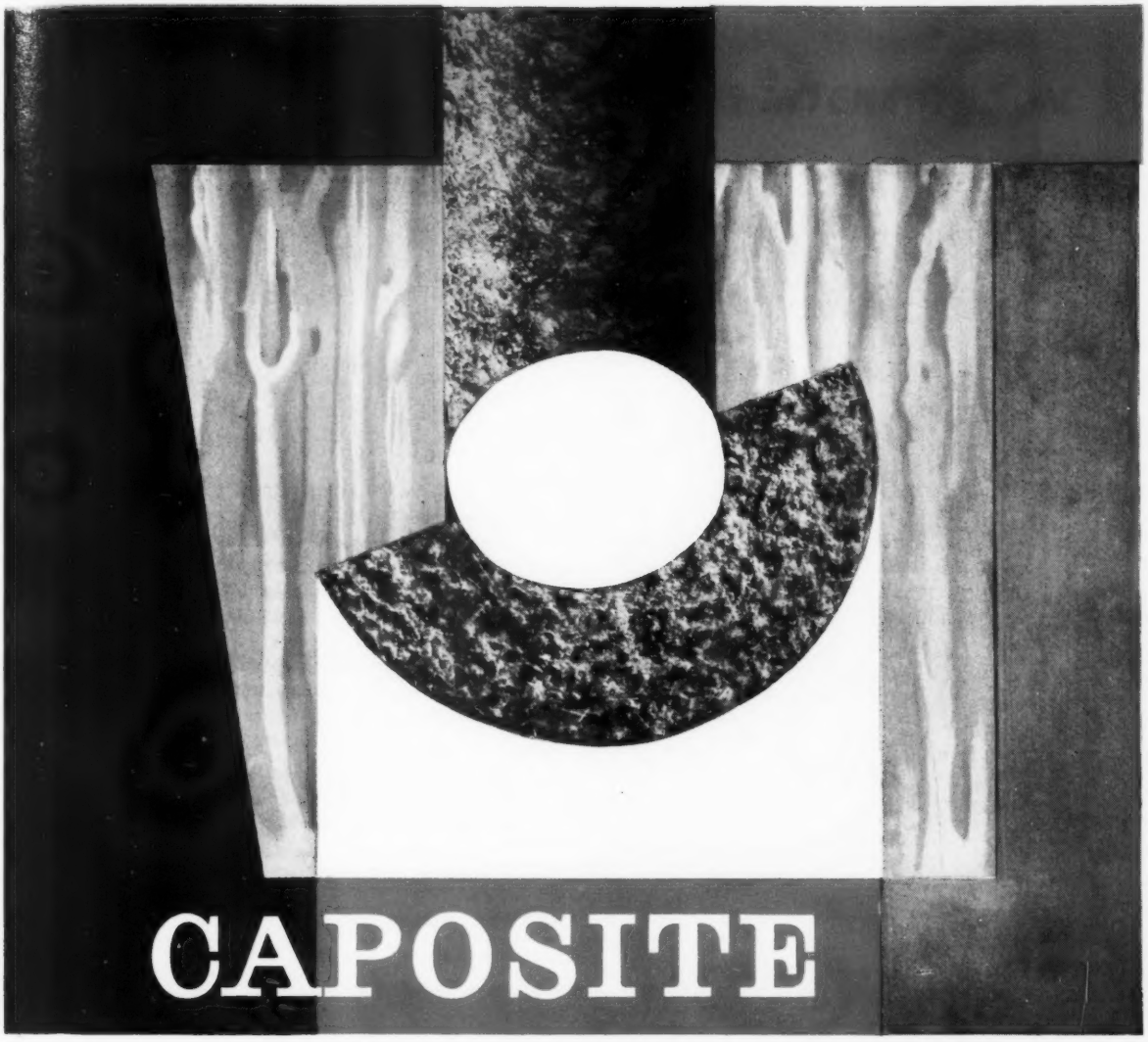
* High impedance input
* High and low level alarms
* Retransmitting slidewire
* Range change switch as well as plug-in bobbins
* Automatic cold junction compensation

All models have a totally enclosed slidewire and continuous stabilisation of the slidewire supply voltage. For full technical information, please contact: SUNVIC CONTROLS LTD., P.O. Box 1, HARLOW, ESSEX. Tel. HARLOW 25271

SUNVIC
An A.E.I. Company

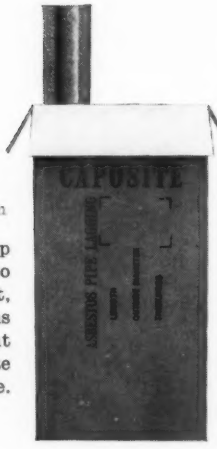
Not only instruments but complete instrumentation
for integrated monitoring, control and data handling of nuclear reactors and industrial processes.

SC/69



INSULATION

'efficient, economical'



CAPOSITE is clean

clean to cut and sweep away—no mess to stick to boots. It comes in light, non returnable cartons which make handy off-cut bins—there's no waste with Caposite.

Caposite insulation has high thermal efficiency due to its being made from unique long fibred amosite asbestos from the company's own mines. These long fibres give Caposite great mechanical strength, enable it to be preformed in large sizes, and to be applied as a single layer.

amosite asbestos preformed insulation

CAPE

THE CAPE ASBESTOS COMPANY LTD

114 & 116 PARK STREET, LONDON W.1. GROsvenor 6022

GLASGOW: Hobden Street, Petershill Road, Glasgow N.1. Springburn 6144
MANCHESTER: Floor D. National Buildings, St. Mary's Parsonage, Manchester 3. Deansgate 6016-7-8
BIRMINGHAM: 11 Waterloo Street, Birmingham 2. Midland 6565-6-7
NEWCASTLE: 19 & 20 Exchange Buildings, Newcastle. Newcastle 20488

TA1631

Tick **No 9** on reply card for further details

first ..... CALDER HALL

Visit the Great

ENGINEERING
MARINE
WELDING
& NUCLEAR
ENERGY
EXHIBITION

OLYMPIA LONDON
16TH–30TH APRIL 1959

SEE US AT
STAND D9.

now ..... CHAPELCROSS

Britain's second nuclear power station, has begun working

Carbon dioxide gas cooling is used at both Calder Hall and Chapelcross, and the bulk storage and vaporization equipment for the coolant was supplied by The Distillers Company Limited.
The D.C.L. system of carbon dioxide bulk storage and supply, operating in conjunction with the D.C.L. fleet of road tankers, has proved itself to be by far the most efficient and economical method for all users of the product, whether large or small.

and ..... When the atomic power stations at Berkeley, Hunterston and Hinkley Point are completed, they too will include D.C.L. carbon dioxide installations.

DCL

CARBON DIOXIDE

BULK STORAGE EQUIPMENT

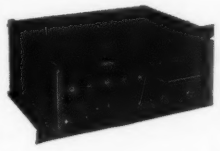
THE DISTILLERS COMPANY LIMITED
CHEMICAL DIVISION, CARBON DIOXIDE DEPARTMENT
Devonshire House, Mayfair Place, Piccadilly, London W.1
Telephone: MAYfair 8867 Telegrams: Cardiox London Telex

TA 2005

IF YOU ARE INTERESTED IN

NUCLEONIC COUNTING

Nucleonic Counting Equipment Type 127A.
Designed specifically for use in the nucleonic field where accurate, high speed counting is essential. This range of equipment comprises Scaling Unit, Amplifier-Discriminator, E.H.T. Unit, Head Amplifier, Quench Unit, Ratemeters and Timing Unit.



Scaling Unit Type 1221C.
A reliable general purpose Scaling Unit with a resolving time of 500μ secs. and a maximum count of 10^5.

G.M. Counter Type 121A.
An inexpensive and reliable low-speed counting equipment for use in schools and technical colleges.

Timing Unit Type 146A.
An advanced design in Timing Units, this instrument employs high speed relay start/stop control.

E.H.T. Power Unit Type 105A.
Designed for nucleonic work—this gives continuously variable stabilized voltages from 300-3,300 volts d.c.

YOU NEED THIS NEW CATALOGUE!

If your interest lies in fact, in any aspect of Nuclear Physics, Radiation Monitoring, Radio-active Ore Surveying and Industrial Control and Measurement, then this new comprehensive catalogue should have a place in your library. Here at Ericsson, research and development are proceeding continuously to widen the range of counting, measuring and control instruments, and we invite you to examine our progress.

CUT OUT AND MAIL TODAY

ERICSSON
INSTRUMENT DIVISION
HIGH CHURCH STREET, NEW BASFORD, NOTTINGHAM.
Please send copy of your catalogue **ELECTRONIC & NUCLEONIC INSTRUMENTS**

NAME_____

ADDRESS_____

_____

POSITION_____

ERICSSON

INSTRUMENT DIVISION

HIGH CHURCH STREET, NEW BASFORD, NOTTINGHAM

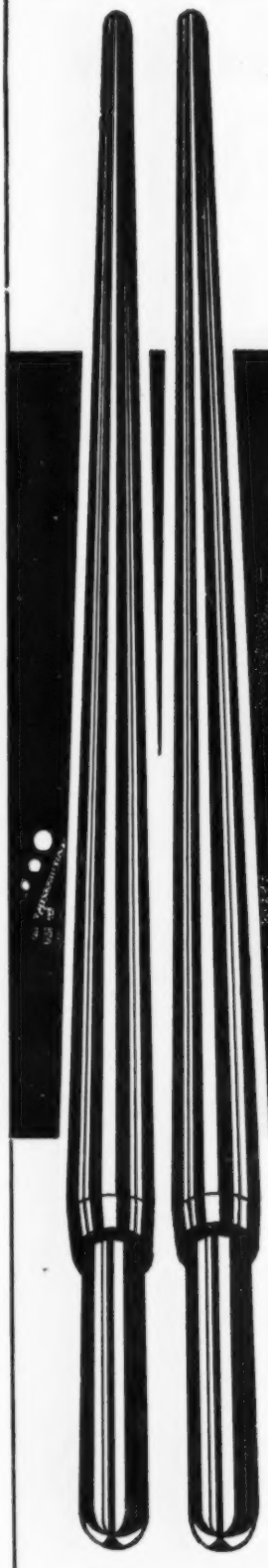
The Authority on Electronic & Nucleonic Counting

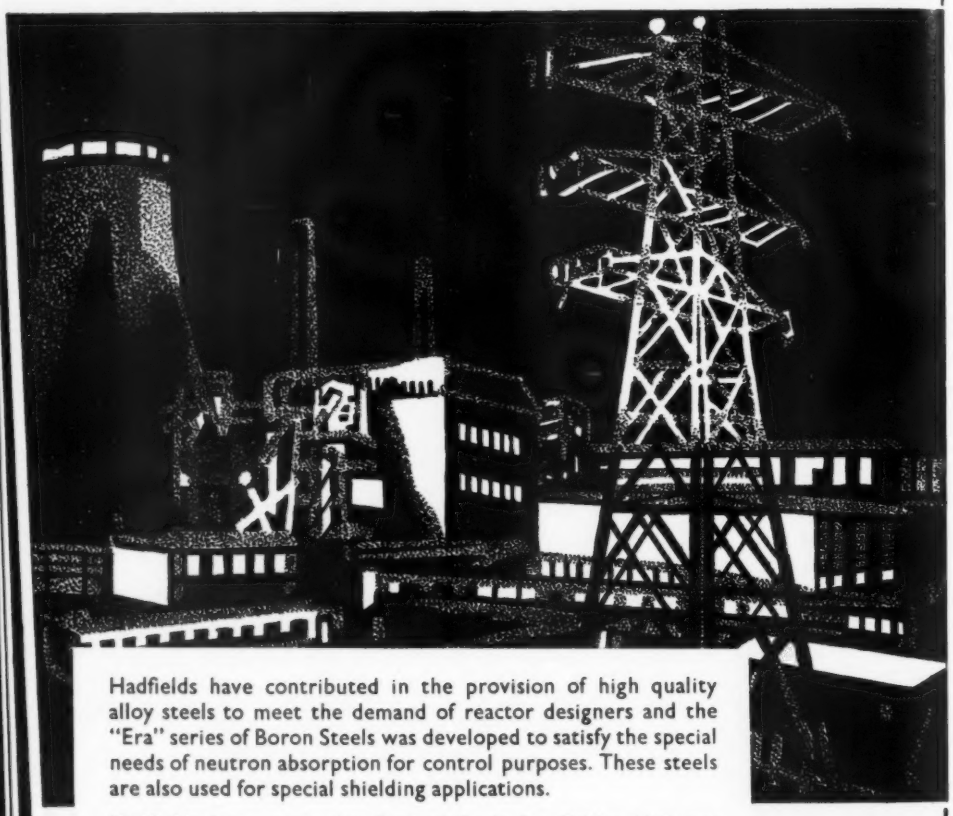
ERICSSON TELEPHONES LTD., HEAD OFFICE: 22 LINCOLN'S INN FIELDS, LONDON, W.C.2 Tel: HOLborn 6936

E106-84A

SPECIAL STEELS FOR NUCLEAR POWER . . .

One of the most essential characteristics implied by the expression 'high quality' is reliability, and the construction of nuclear power plants ranks high amongst those advanced engineering projects, where any doubt concerning the materials of construction cannot be tolerated





Hadfields have contributed in the provision of high quality alloy steels to meet the demand of reactor designers and the "Era" series of Boron Steels was developed to satisfy the special needs of neutron absorption for control purposes. These steels are also used for special shielding applications.

Hadfields have made the Control Rods for Calder Hall and Chapelcross Stations of U.K.A.E.A., incorporating "Era Boron Steels" and "Era H.L.C." special Low Cobalt Stainless Steel. "Era H.L.C." Steel has also been used in the production of a number of other reactor components and is of the 18/8 Stabilised type.

Pressure vessel and heat exchanger forged flanges are made in special "Era C.R." and "Hecla" Steels, and a large number of small castings can be produced in our foundries which are specially equipped for this class of work.

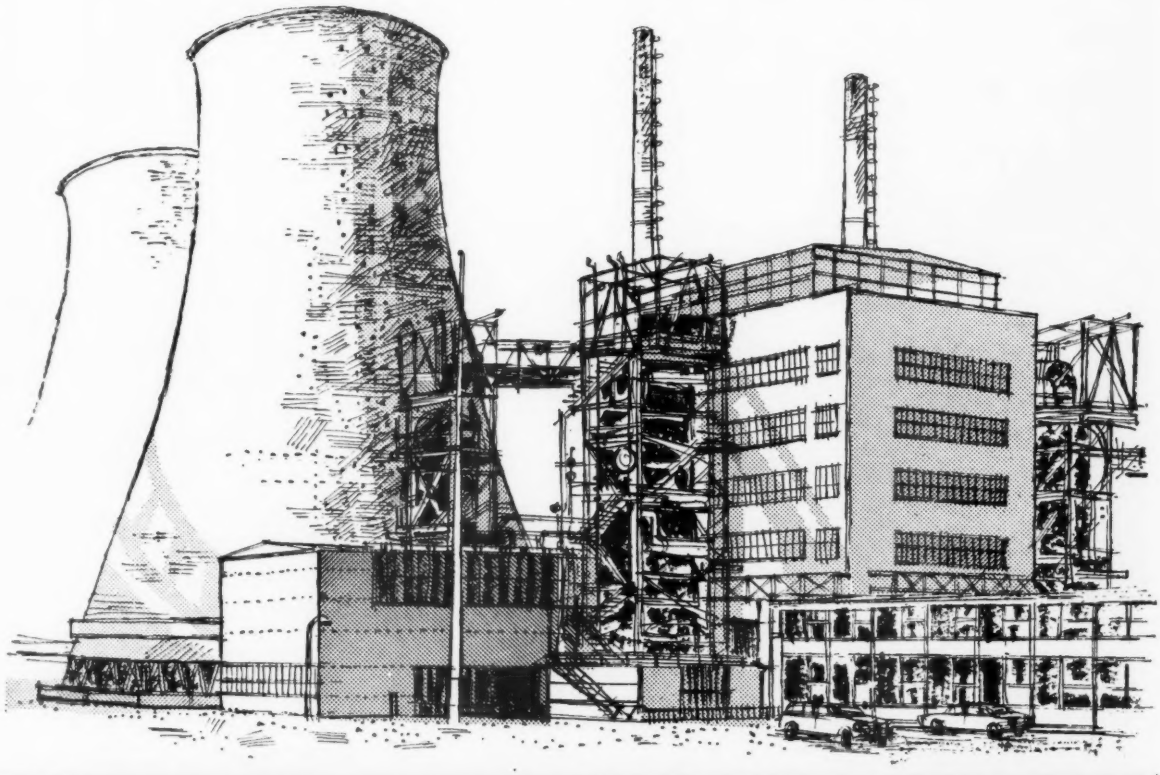
HADFIELDS
SHEFFIELD

HADFIELDS LTD., EAST HECLA WORKS, SHEFFIELD, ENGLAND.

SERCK

the SERCK organisation

is actively concerned in the supply of equipment and material with special application to the Nuclear Power Industry



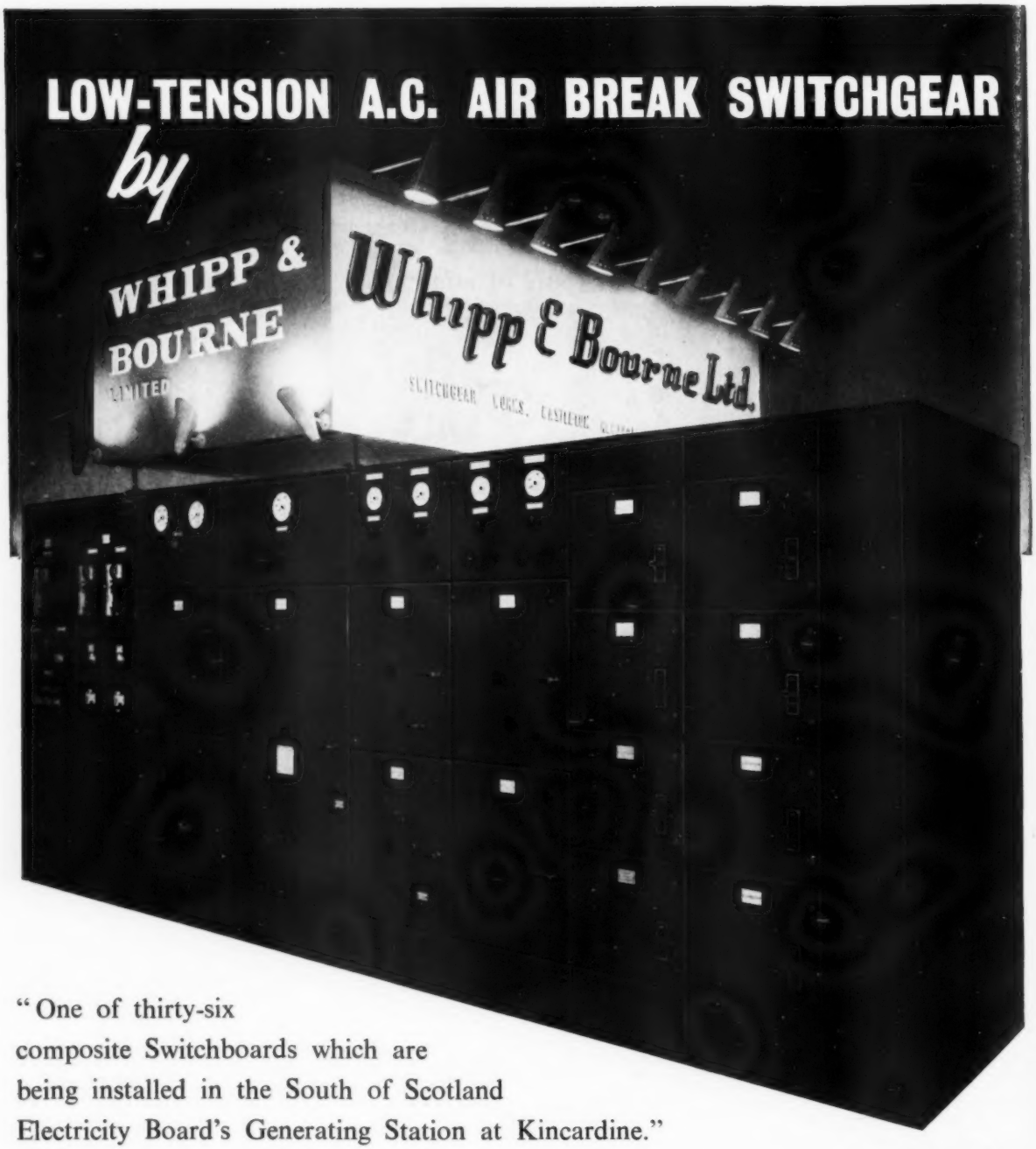
Primary and Secondary surface heat exchangers, Condensers, Air and Gas coolers, Condenser tubes

SERCK RADIATORS LIMITED
SERCK TUBES LIMITED

LOW-TENSION A.C. AIR BREAK SWITCHGEAR

by

WHIPP & BOURNE LIMITED



"One of thirty-six composite Switchboards which are being installed in the South of Scotland Electricity Board's Generating Station at Kincardine."

AIR-CIRCUIT BREAKERS, COPPER CONNECTIONS, AND BUS BARS TESTED IN ACCORDANCE WITH A.S.T.A. 16.

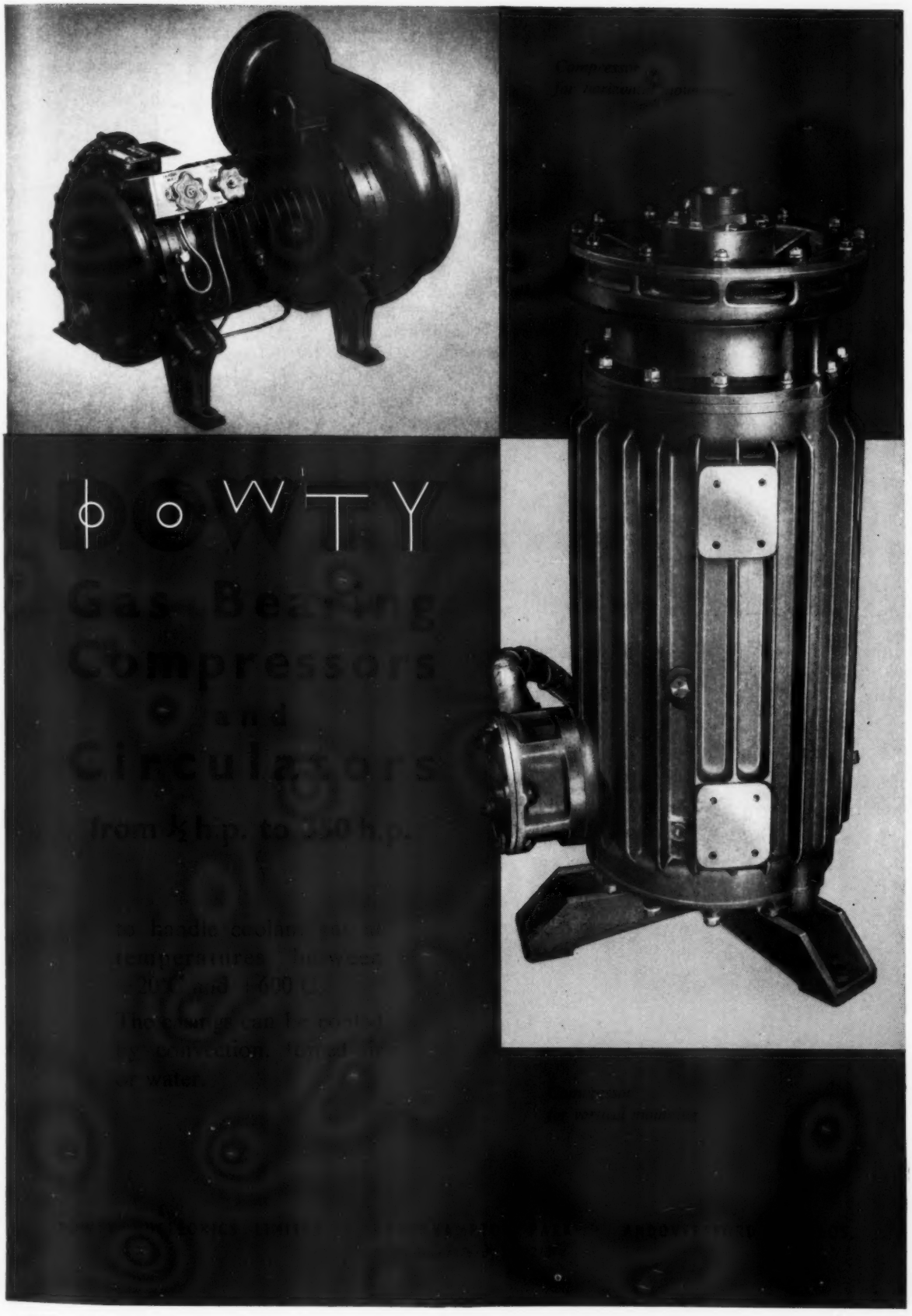
CONSULTING ENGINEERS - MESSRS. KENNEDY & DONKIN

FOR LEAFLET IF/2 WRITE TO

Manufacturers of Air Break Circuit Breakers for the past fifty years

Whipp & Bourne Ltd

SWITCHGEAR WORKS CASTLETON · ROCHDALE · LANCS



Tick **No 15** on reply card for further details

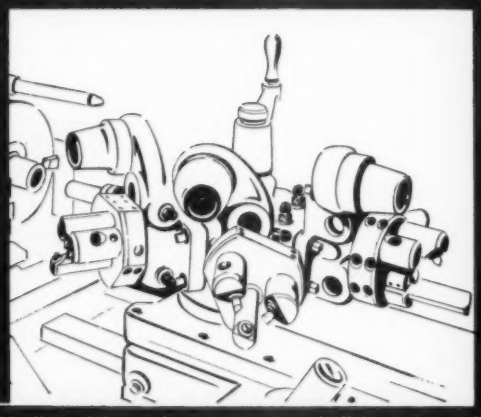
FREE CUTTING BRONZES AND BRASSES

✻ Free Cutting Brass for use at the highest machine speeds.
Available as rods, bars, tubes, solids and hollow shapes.

✻ High strength Bronzes and Brasses with good machining properties.

✻ Close metallurgical control at all stages of manufacture.

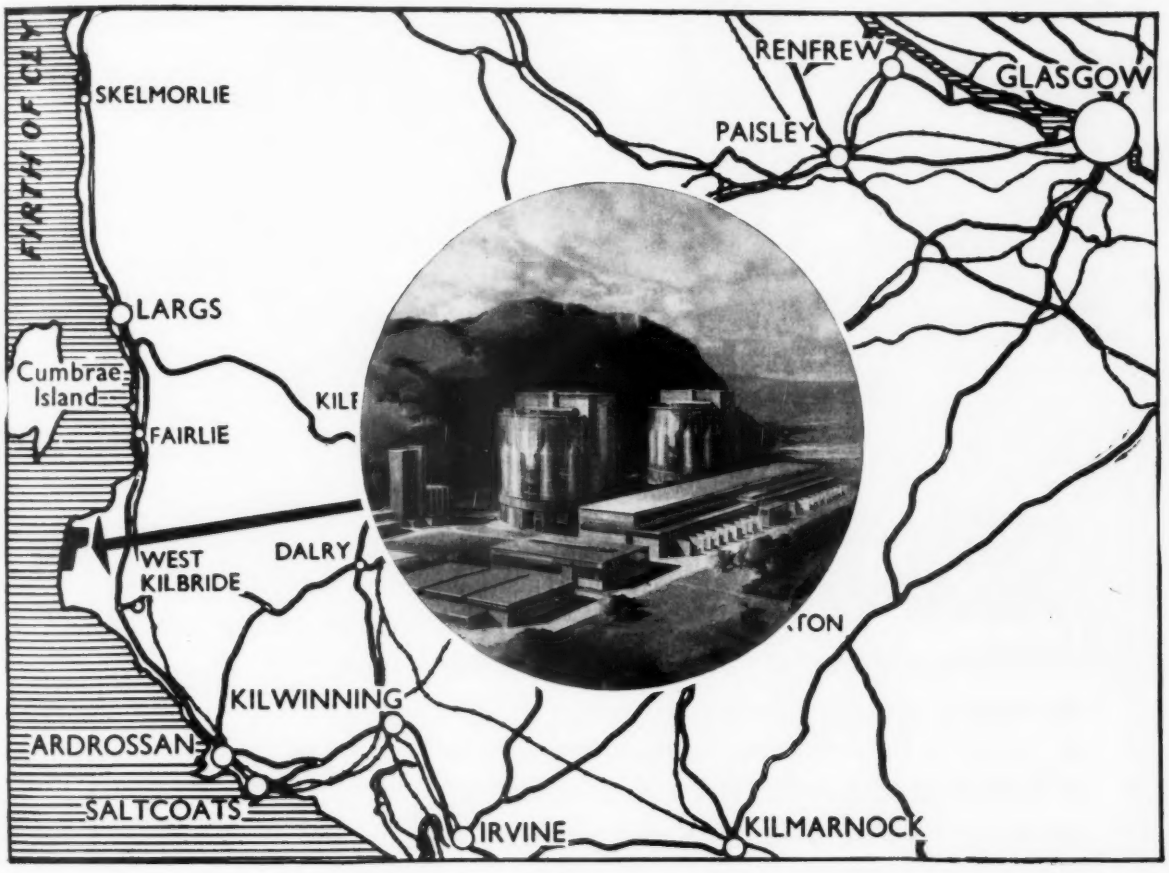
✻ Alloys produced to all British and other standard specifications.



THE MANGANESE BRONZE AND BRASS COMPANY LIMITED

P.2383

The Power of the Atom



at Hunterston

Simon-Carves are responsible for nearly half the contract value of the South of Scotland Electricity Board's nuclear power station at Hunterston. This responsibility embraces design and supervision of all civil engineering construction works, including biological shieldings and their cooling systems, all steel structures and building superstructures, the condenser circulating water system and water treatment plants, and the sixteen steam-raising units and auxiliary equipment associated with the two nuclear reactors. At the same time the Simon-Carves research organisation and the international experience of Simon-Carves in heavy engineering design and large-scale contracting are being applied, in association with The General Electric Co Ltd of England, to the development of even more advanced nuclear power stations in Great Britain and throughout the world.

Simon-Carves Ltd

SIMON ENGINEERING GROUP

NUCLEAR POWER DIVISION | Cheadle Heath, Stockport

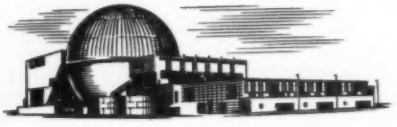
IN ASSOCIATION WITH THE GENERAL ELECTRIC CO LTD OF ENGLAND

SC202

Tick No 17 on reply card for further details

BY APPOINTMENT TO HER MAJESTY THE QUEEN
Suppliers of Fire Extinguishers *The Pyrene Company Limited*

facing new fire problems in the sphere of nuclear power



The Pyrene Company, with its unrivalled facilities for research, keeps ahead of changing industrial techniques, and is constantly developing the means to overcome the new fire risks they involve. As makers of the world's most comprehensive range of fire-fighting equipment, The Pyrene Company can give you invaluable and impartial advice on any fire protection problem—it is yours for the asking.

We are proud to have given advice on fire protection—and supplied major fire-fighting equipment—for most British atomic centres already constructed. Consult Pyrene Fire Engineers and ensure maximum fire protection for valuable plant and human lives too.

Pyrene TRADE MARK FIRE APPLIANCES

protect

ALDERMASTON
CALDER HALL
CAPENHURST
DOUNREAY · FOULNESS
HARWELL · SPRINGFIELD
WINDSCALE

Pyrene TRADE MARK FIRE FIGHTING EQUIPMENT

THE PYRENE COMPANY LIMITED

(Dept. NP 14) 9 GROSVENOR GARDENS · LONDON S.W.1 *Tel:* VICtoria 3401

Head Office & Works: GREAT WEST ROAD · BRENTFORD · MIDDX

Canadian Plant: TORONTO *Australian Plant:* MELBOURNE

Tick **No 18** on reply card for further details

RENOLD *CHAINS AND ATOMIC POWER*

Right from the cutting of the foundations, machines equipped with Renold chain are speeding the erection of Britain's atomic power stations — trench-diggers, excavators, dumpers, bulldozers, motor graders, all relying on the dependability . . . the robustness . . . the efficiency of Renold chains.

If you have a problem involving drives, conveyors or operating devices, Renold chains can provide the answer— our engineers are always available for consultation.

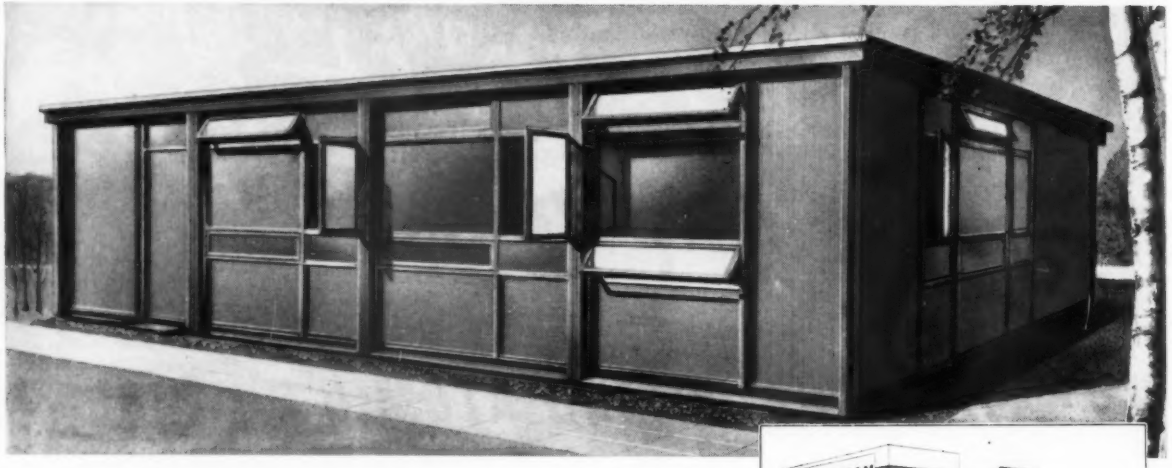
RENOLD CHAINS

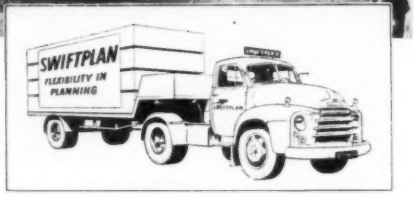
RENOLD CHAINS LIMITED · MANCHESTER

Tick No 19 on reply card for further details

Announcing
SWIFTPLAN
FLEXIBILITY IN PLANNING

—A MAJOR ADVANCE IN FULLY EQUIPPED MOBILE BUILDINGS





Swiftplan Units (25 feet long by 8 feet wide) can be used in combination to form single, double or multispan buildings.

SWIFTPLAN STAR FEATURES

UNIQUE FLEXIBILITY
in planning and design

UNINTERRUPTED FLAT CEILINGS

REMARKABLE EASE AND SPEED IN ERECTION
a block a day!

MINIMUM SITE COSTS

QUALITY MATERIALS
for strength and durability

PRECISION BUILT—ENGINEER TESTED

ECONOMICAL TRANSPORT
(four units per vehicle)

100% RECOVERY VALUE

COMPLETE WITH DECORATIONS · FLOOR COVERINGS
LIGHT · HEATING · PLUMBING *as required*

AND THE SWIFTPLAN ALL-IN SERVICE
PLANNING · TRANSPORT · ERECTION · RE-SITING

Here at last in Swiftplan you have all the advantages of a precision-built mobile building *plus* real freedom and flexibility in your planning and design! Doors, windows, etc., just where *you* want them—without extra charge! Far greater flexibility in positioning partitions, and a choice of alternative *heights* of building. (And—what is surely long overdue—uninterrupted *flat* ceilings!) Swiftplan opens the way to altogether new standards of efficient planning and aesthetic design. From every point of view—speed, quality, durability, economy—Swiftplan units excel. Write today for illustrated leaflet, and, if you have any accommodation problem on your hands, send us details and we will gladly advise you free and without obligation.

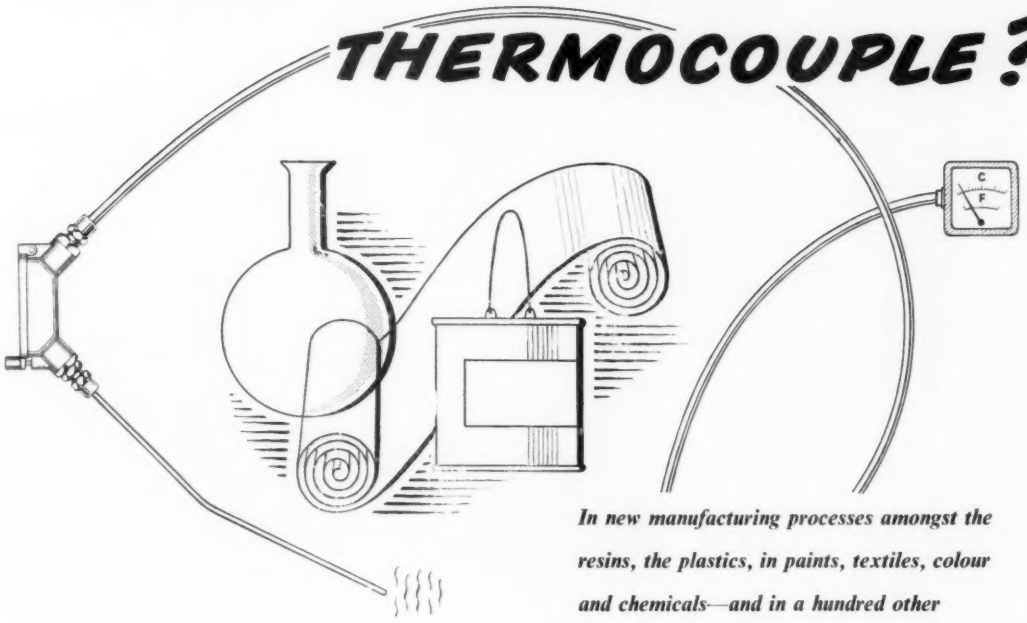
SWIFTPLAN
LIMITED

39 VICTORIA STREET · LONDON · S.W.1
Telephone: Abb.y 4393

MOBILE OFFICES · RAILWAY STATIONS · WORKSHOPS · STORES · CANTEENS · CAMPS · ABLUTIONS

Tick **No 20** on reply card for further details

What do you expect of a THERMOCOUPLE?



In new manufacturing processes amongst the resins, the plastics, in paints, textiles, colour and chemicals—and in a hundred other spheres—temperature control is playing a bigger and more vital part.

Higher accuracies, quicker responses, longer life—these are the demands imposed by today's thermo-instrumentation. And, these too, are the inherent features of 'Pyrotenax' Thermocouples. Add to these the characteristics shown and you have the reasons why 'Pyrotenax' Thermocouples are the considered choice of the scientist and technician behind such projects as Bradwell and Calder Hall etc. and other famous enterprises in Industry.

'Pyrotenax' Thermocouples are supplied with conductors of COPPER/CONSTANTAN with either CUPRO-NICKLE or MILD STEEL sheath, conductors of NICKEL-CHROME/NICKEL ALUMINIUM ALLOY with NICKEL-CHROME STEEL sheath for high accuracy, high temperature applications.

Full Technical details in Publication 31/X110

Pyrotenax

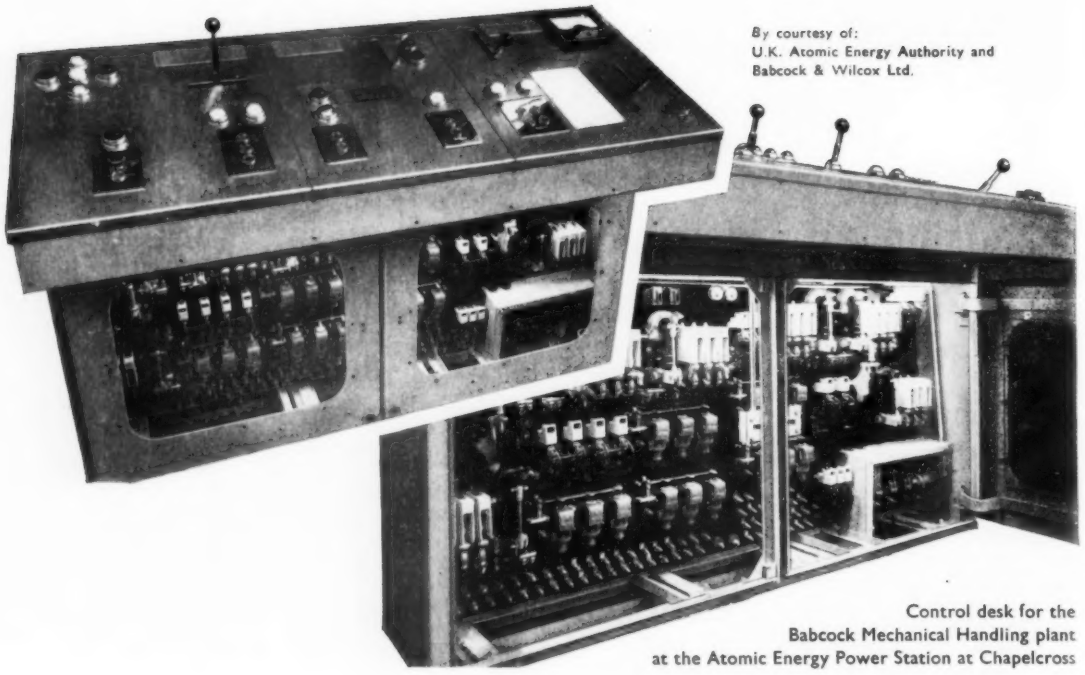
MINERAL INSULATED THERMOCOUPLES

Use of the name "Pyrotenax" is exclusive to the products of this company and its associates.

✓	**EASILY BENT TO SHAPE**
	they are
✓	**IMMUNE FROM THERMAL SHOCK AND MECHANICAL DAMAGE**
	their
✓	**SMALL OVERALL DIAMETER** permits use in restricted spaces allowing simultaneous readings at different points, where normally only one conventional type could be sited, and generally
	NO ADDITIONAL PROTECTIVE
✓	**SHEATHING REQUIRED** *resulting in a*
	RAPID RESPONSE RATE
✓	comparable with that of mercury-in-glass thermometer
	They have a
✓	**LONG LIFE**
	but, because they are
✓	**INEXPENSIVELY REPLACED** they may be used at temperatures far in excess of those normally permitted for economic operation

PYROTENAX LIMITED HEBBURN-ON-TYNE *Telephone: Hebburn 83-2244/8*

LONDON: *Abbey 1654/5* • **BIRMINGHAM**: *Midland 1265* • **MANCHESTER**: *Blackfriars 6946* • **LEEDS**: *Leeds 27826* • **GLASGOW**: *City 3641/2* • **CARDIFF**: *Cardiff 23689*
GD110



By courtesy of:
U.K. Atomic Energy Authority and
Babcock & Wilcox Ltd.

Control desk for the
Babcock Mechanical Handling plant
at the Atomic Energy Power Station at Chapelcross

EMB at Chapelcross

Chapelcross Power Station now feeding into the grid—Congratulations to all concerned!

E.M.B. Control Gear especially with MICROsen A.C. Speed control unit is being used to an ever increasing extent for Atomic Power Stations.

If the conditions are exacting there you will find E.M.B. equipment giving excellent service.

E.M.B. Co. Ltd.

WEST BROMWICH
ENGLAND

AIRMEC INSTRUMENTATION

keeps in step with nucleonic needs

MONITORS

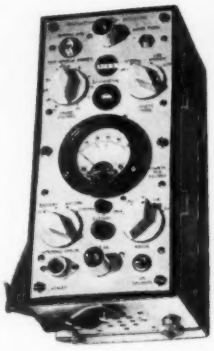
RADIATION MONITOR *Type 1021 B*

- ★ **SAFEGUARDS against contamination.**
- ★ **TRACES radio-active material in chemical analytic processes.**
- ★ **MEASURES contamination of any resulting effluent.**

Designed in conjunction with A.E.R.E. Harwell, this instrument is probably the most widely used general purpose monitor in the world. It has been PROVED by years of user experience to be the most accurate and reliable equipment of its type.

The Radiation Monitor consists of a mains operated Indicator Unit together with a Beta Gamma or Alpha Probe Unit. Indication is provided visually by means of a meter which is calibrated in counts per second, and audibly by means of a loudspeaker. A socket on the front panel is also provided to enable the output to be fed to a scaling unit.

Write for descriptive leaflet No. 26D giving full details.



RADIATION MONITOR *Type 255*

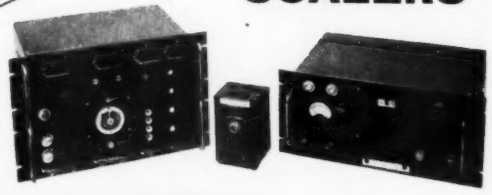
- ★ **Transistorised, battery operated, portable.**
- ★ **Laboratory accuracy under field conditions.**
- ★ **Wide range of probes and accessories available.**

Airmec are proud to be the first to announce a fully transistorised monitor which combines laboratory accuracy with complete portability. The uses include:

1. Checking the presence and amount of radio-active contamination in laboratories and workshops.
2. Checking atmosphere 'fall-out' and contamination of food, animals, crops, milk and water supplies, etc.
3. Following the progress of radio-active tracer elements in medical, geological, agricultural and industrial processes.
4. Tracing the whereabouts of radio-active areas and making accurate assays of samples in geological surveys.
5. Tracing lost samples of radio-active materials both in buildings and out.

Write for descriptive leaflet No. 177

SCALERS



GENERAL PURPOSE COUNTER *Type 1339 A*

- ★ **Designed and developed in conjunction with U.K.A.E.R.E.**
- ★ **Provides comprehensive scaling facilities for all types of Geiger] Scintillation Counters.**
- ★ **Incorporates stabilised E.H.T. supplies.**
- ★ **Fitted with automatic timing control.**

This equipment is built on a unit basis and provides very comprehensive scaling facilities for all types of accurate assay work. It consists of two main units — a Power Unit and a Scaling Unit — together with a number of optional sub-units. These include a Quenching Unit, a High Speed Scaling Unit, an Amplifier/Discriminator Unit, a Paralysis Unit and a Timing Unit.

Full details are given in descriptive leaflet No. 185

Airmec

INSTRUMENTS FOR THE NUCLEONIC INDUSTRY

AIRMEC LIMITED · HIGH WYCOMBE BUCKS

Telephone : High Wycombe 2060

Tudor

are pleased to announce that they have

been awarded contracts for supplying

batteries and associated equipment for

HUNTERSTON

(Sub-Contract from the General Electric Co. Ltd.)

BRADWELL

(Sub-Contracts from The Nuclear Power Plant Co. Ltd., and A. Reyrolle & Co. Ltd.)

Tudor have also supplied batteries and associated equipment to the following nuclear power stations:

CALDER HALL 'A'
CALDER HALL 'B'
CHAPEL CROSS
DOUNREAY

(Supplied under sub-contracts from:
A. Reyrolle & Co. Ltd.
The English Electric Co. Ltd.
Brush Electrical Engineering Co. Ltd.)

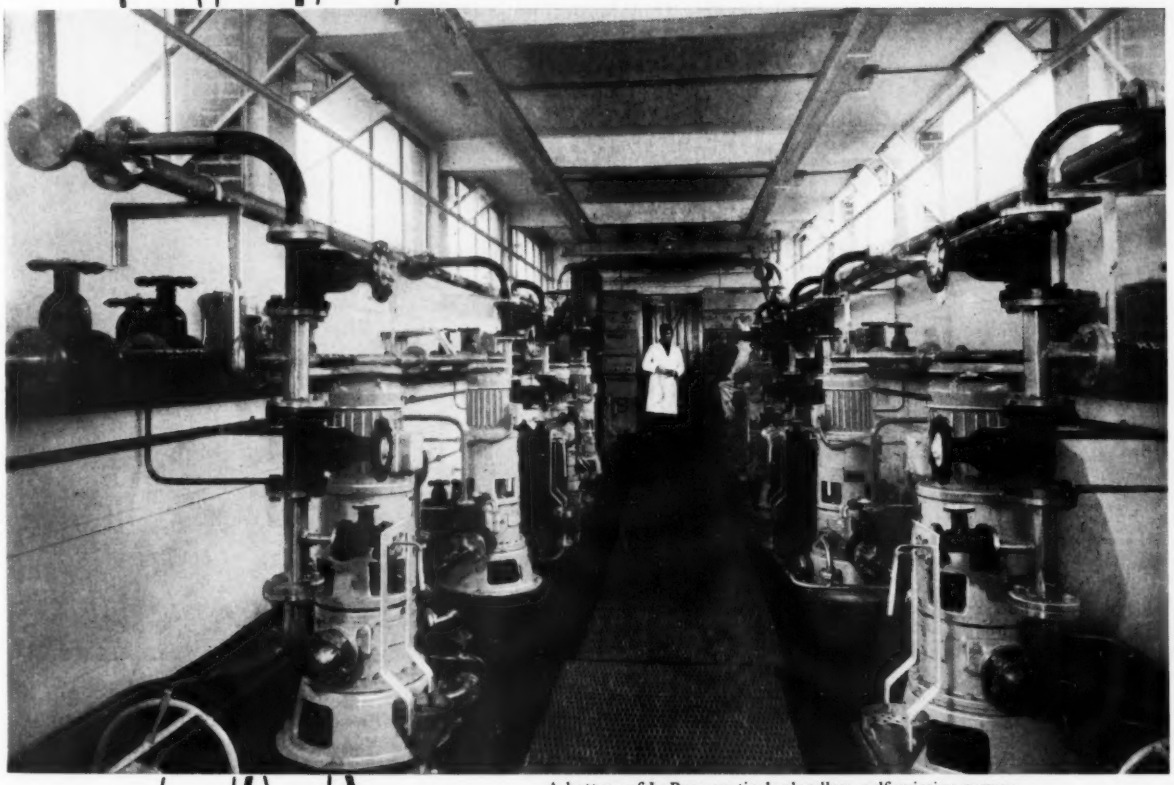
Tudor

Specialists in battery work for nuclear power stations

THE D.P. BATTERY COMPANY LTD., BAKEWELL, DERBYSHIRE. TEL.: BAKEWELL 581-5

T.170

APPROVED BY
UNITED KINGDOM ATOMIC ENERGY AUTHORITY



A battery of LaBour vertical, glandless, self-priming pumps.
(Photograph by courtesy of the United Kingdom Atomic Energy Authority)

More than 250 LaBour pumps have been installed at one establishment alone of the U.K.A.E.A. Whether it is liquors or slurries, chemicals or effluents, mine dewatering etc., experienced engineers repeatedly specify LaBour pumps. They know that the simple, one-moving-part design assures uninterrupted service, long life and reduced maintenance. They appreciate the 'extra' features that LaBour pumps have—extra thick sections and extra heavy bearings which mean rigidity; the extra deep stuffing box; and the extra special materials which give extra resistance to corrosion and erosion.

VISIT OUR EXHIBITS ON STAND NO. 3, ROW P
NATIONAL HALL, OLYMPIA, LONDON, 16th—30th APRIL, 1959

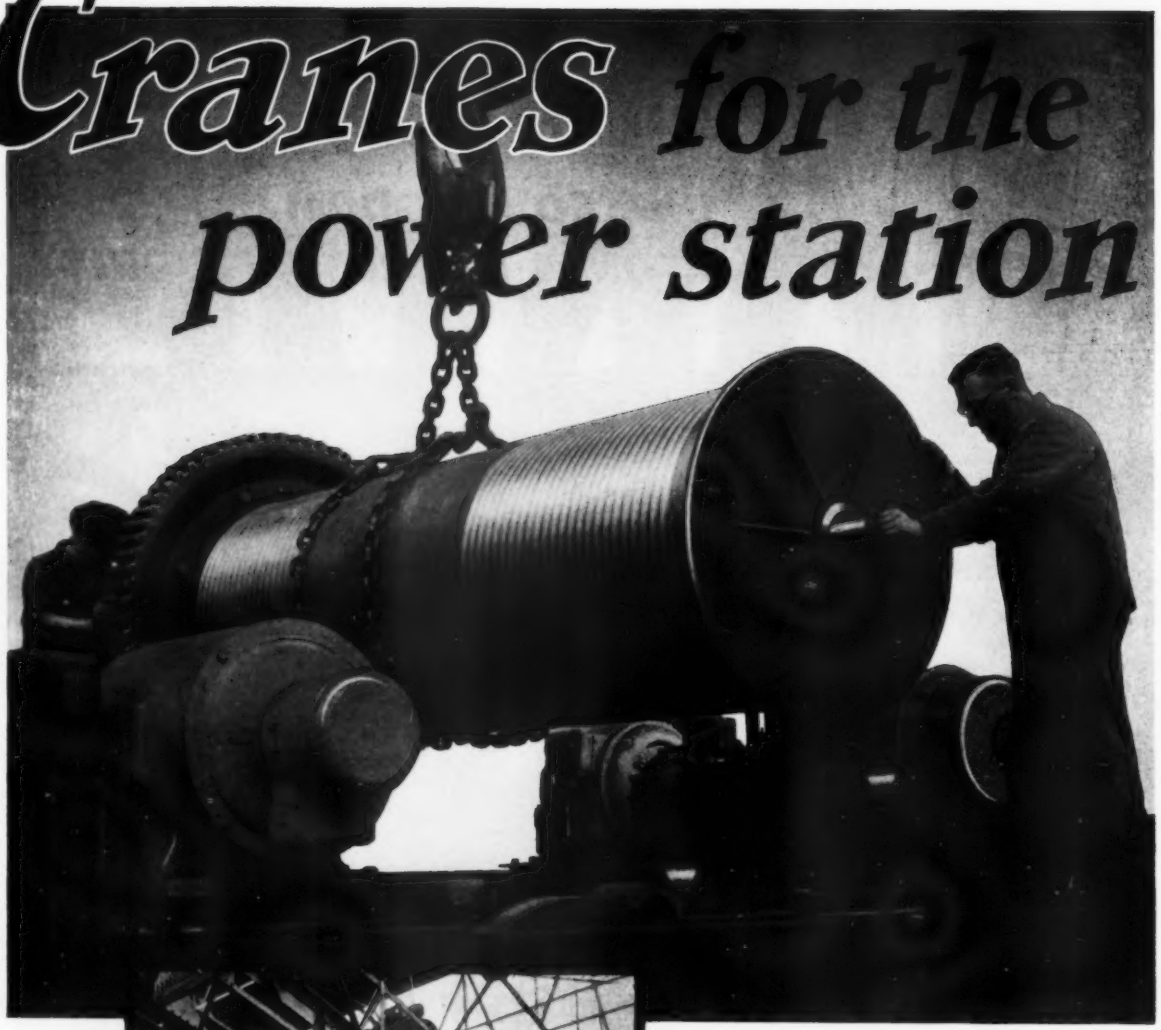
LABOUR

BRITISH LABOUR PUMP CO. LTD. BLUNDELL ST. LONDON N7 TEL: NORTH 6601-5

P2320

Tick **No 25** on reply card for further details

Cranes for the power station



THE massive rope drum for a 110-ton Morris crane is here shown being lowered on to the crab frame. Behind the drum is the crab traversing gear and the auxiliary lifting gear which in this instance is for a capacity of 10 tons. The crane was despatched to a power station in India—one more to the long list of Morris cranes already giving reliable service in power stations all over the world.

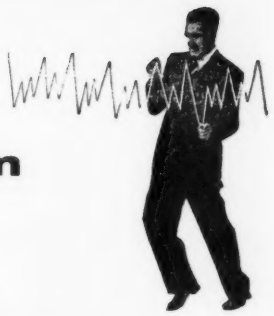
MORRIS

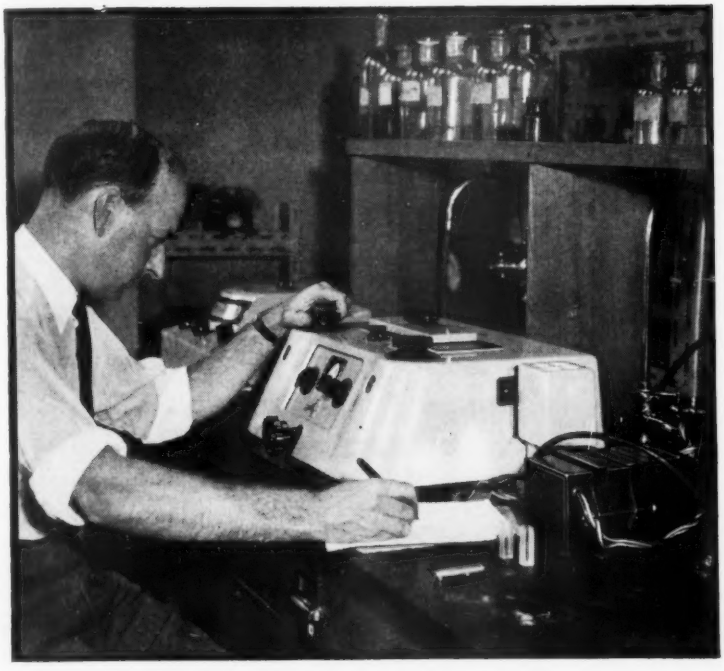
HERBERT MORRIS LTD P.O. Box 7 LOUGHBOROUGH ENGLAND **TELEPHONE: LOUGHBOROUGH 3123**

INCORPORATING ROYCE LTD. AND CRAVEN BROS. (CRANE DIVISION) LTD.

C V T

A Mains Voltage Fluctuation problem





A Unicam type S.P. 600 Spectrophotometer in use with an 'Advance' C.V.T.

in Absorption Analysis

The Spectrophotometer employs a particular optical/electronic system in which a light source, photocells and special amplifier play a vital part. Vital, because it is upon their correct performance characteristics that the accuracy of the instrument depends.

But their correct performance, in turn depends upon a stable supply voltage. How is this achieved?

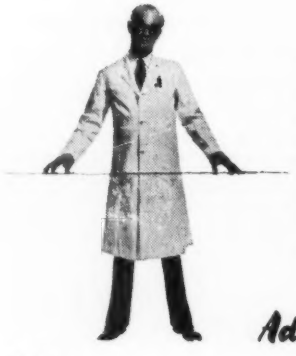
. . . straightened out by

In the Unicam S.P. 600 Spectrophotometer illustrated the tungsten lamp and valve heaters in the amplifier are supplied from the mains through an 'Advance' Constant Voltage Transformer (seen on the right of photograph). As a result the accuracy of the instrument is unaffected by fluctuating supply voltage.

'Advance' Constant Voltage Transformers provide a.c. voltage stabilization of ± 1% for imput variations of up to ± 15% at maximum load. For power requirements from 4 to 6000 watts, they are automatic and contain no moving parts.

Advance

CONSTANT VOLTAGE TRANSFORMERS



'VOLTAGE STABILIZATION'

This 'Advance' Booklet gives authoritative information on 'Advance' Constant Voltage Transformers, and the service available to deal with your particular voltage fluctuation problems. Send for a copy.

POST THIS COUPON TO-DAY ▶

TO ADVANCE COMPONENTS LIMITED
ROEBUCK ROAD, HAINAULT, ILFORD, ESSEX

Please send me a copy of your booklet "Voltage Stabilization by Advance.

NAME .....

POSITION .....

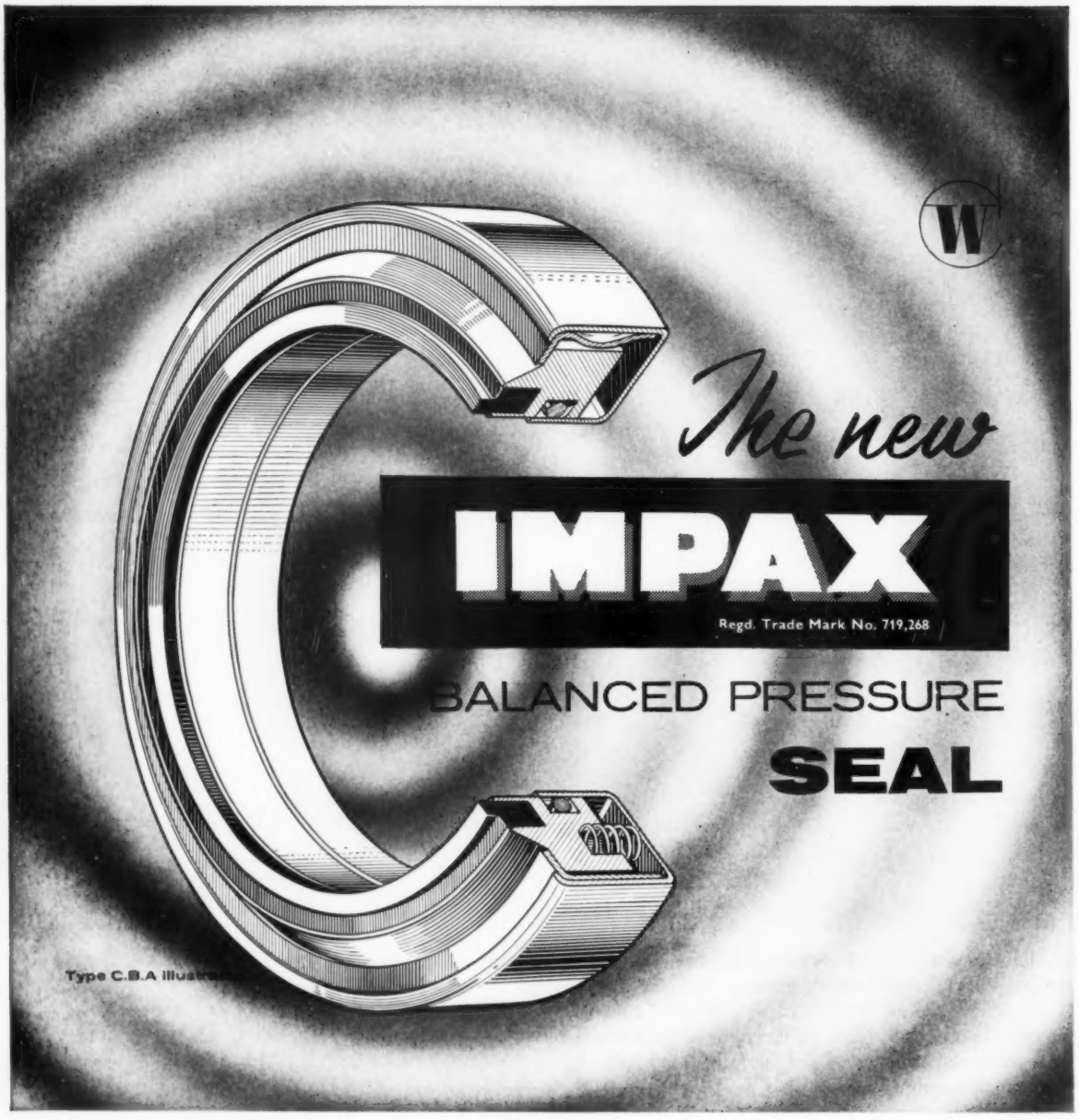
COMPANY .....

ADDRESS .....

..... N 13

Advance COMPONENTS LIMITED · ROEBUCK ROAD · HAINAULT · ILFORD · ESSEX · TELEPHONE: HAINAULT 4444

GD 13



FOR SHAFTS ROTATING AT HIGH SPEEDS

Ensure 100% OCCLUSION. Specially designed and produced for the purpose – Weston IMPAX Seals are established for use on high speed rotating shafts, coupled with high fluid temperatures and pressures. A new series has been developed, using the most advanced materials to keep pace with the quickening tempo of modern machine operation.

Send for new Catalogue now to: Complete range of Seals available.

CHARLES WESTON & CO. LTD.

Irwell Bank Works, Douglas Green, Pendleton, Salford, 6

Telephone: Pendleton 2857-8-9. Telex: 66-255 · Birmingham: Erdington 5459 · London: Holborn 0414. Telex: 2-2682

'FLUON' INCREASES PRODUCTION IN THE ELECTRICAL INDUSTRY

The Dunlop Rubber Co. Ltd. supplied the 'Fluon' covering for the rollers in this 24-channel oscillograph recorder made by Southern Instruments Ltd., Camberly.

'Fluon' rollers used on 24-channel oscillograph recorders

ROLLERS ON THIS E.2400 24-channel cathode ray oscillograph recorder and auto processor unit are made from 'Fluon' p.t.f.e. Into this machine photographic paper in 200-ft. rolls, 40 in. wide is fed. A record emerges developed, fixed and dried at about 1¼ in. per second.

'Fluon' was chosen for the rollers because of its remarkable non-stick properties. It will greatly reduce any risk of the paper breaking as it emerges from the machine.

'Fluon' is the most inert of all plastics and has an extremely wide working temperature range from +250°C. down to liquid nitrogen temperatures. It is very strong yet flexible and among other features are its non-wetting properties.

'FLUON'

'Fluon' is the registered trade mark for the polytetrafluoroethylene manufactured by I.C.I.

IMPERIAL CHEMICAL INDUSTRIES LIMITED · LONDON · S.W.1

PF.48

MoS_2 IN AN AEROSOL SPRAY

ROCOL ANTI-SCUFFING SPRAY

applies the new MOLYBDENUM DISULPHIDE dry lubricant

This speedy, convenient method of application is invaluable for 'on the spot' attention, where parts cannot be segregated for special treatment. Strongly recommended to Service and Maintenance Engineers, Machine and Plant Operators, this method of application is ideally suited for assembly and replenishment of dry lubricating films. Excellent for use on engines, open bearings and chains working in extreme temperatures; on slides, runways, moulds, dies and all press working tools.

THE AEROSOL PACK of 12oz. capacity is available now.

(Single packs 25/- each; 3 doz. packs 24/- each; 1 gross 23/- each). Full instructions for use are printed on each pack.

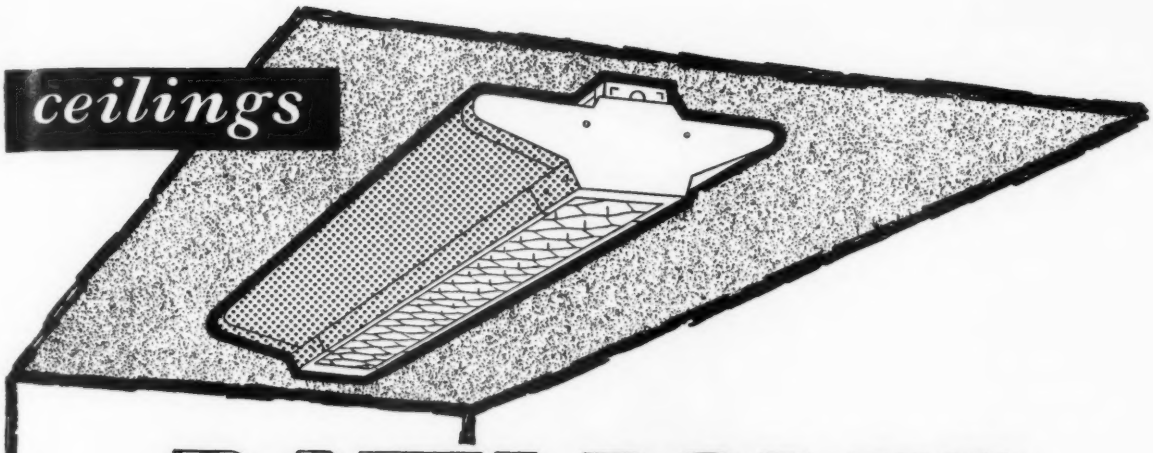
A **Rocol** PRODUCT

Write for descriptive leaflet to:—

ROCOL LIMITED

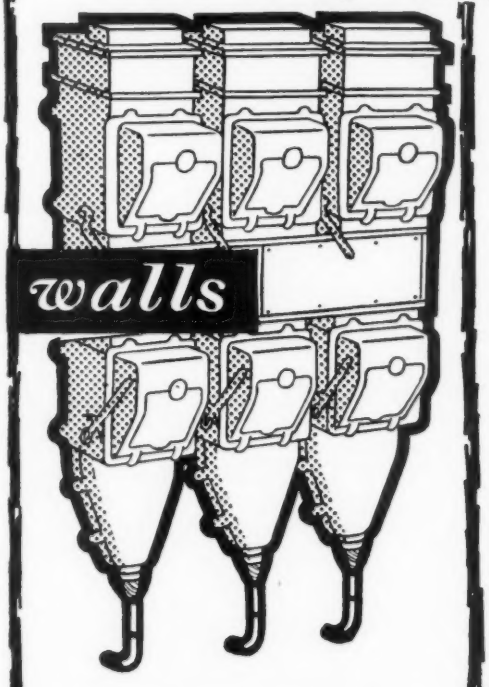
GENERAL BUILDINGS · ALDWYCH · LONDON W.C.2 · 'PHONE HOLBORN 1935/6 · ROCOL HOUSE SWILLINGTON LEEDS 'PHONE GARFORTH 2261/3

ndh 11147C



RAWLBOLTS

For heavy fixing to Ceilings, Walls & Floors



Rawlbolt fixings in concrete, whether in ceilings, walls or floors, are fast and efficient and make real savings in time and money.

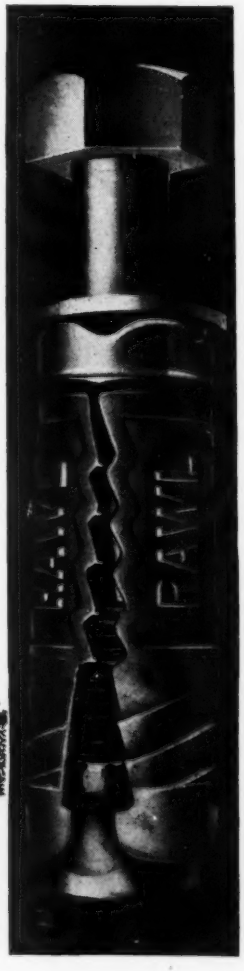
Older methods of fixing involve laborious chiselling of holes, grouting in and waiting several days for cement to harden. With Rawlbolts, the job is far simpler and quicker. Drill a hole, insert a Rawlbolt and tighten up. Your equipment is fixed and ready for use immediately.

Civil Engineers, Consulting Engineers, Building Contractors, Structural Engineers are large and regular users of Rawlbolts.

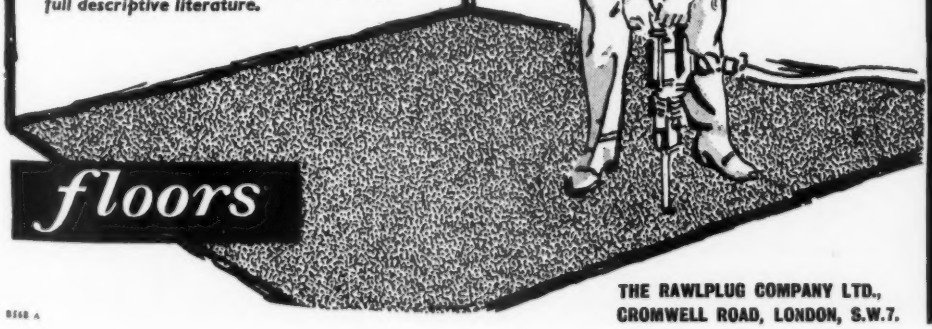
TWO TYPES OF RAWLBOLT

LOOSE BOLT TYPE for fixing to floors

BOLT PROJECTING for fixing to walls and ceilings



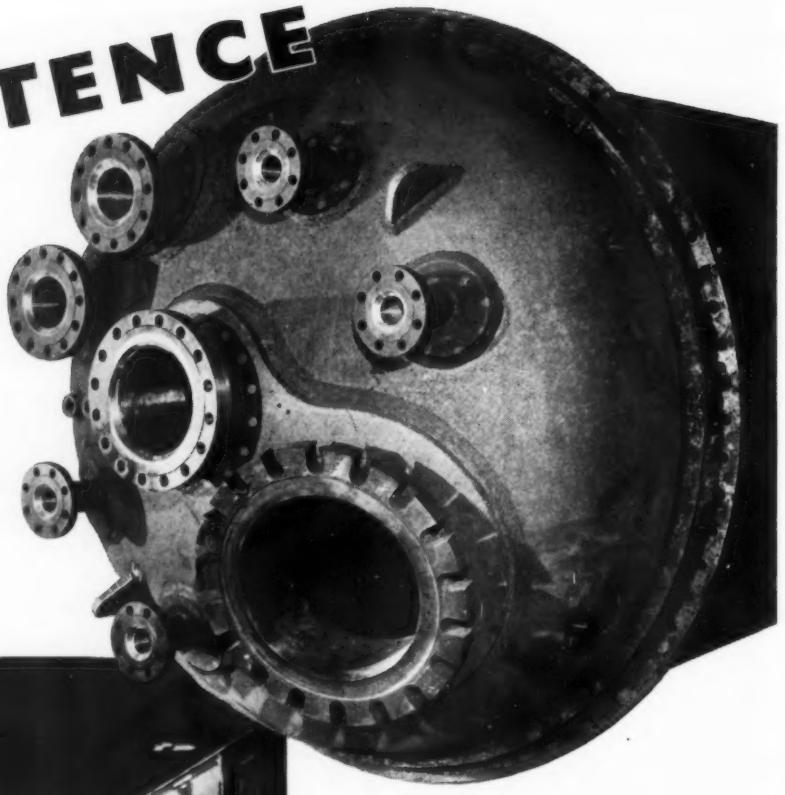
For more information, please write for Dimensional Chart of the Rawlbolt Range and full descriptive literature.



THE RAWLPLUG COMPANY LTD., CROMWELL ROAD, LONDON, S.W.7.

D568 A

COMPETENCE



Head of a 6ft. dia. Autoclave, spun on the Harvey "Rotarpress" from a stainless steel disc 1⅛ in. thick.
Designed for a working pressure of 500 lb./sq. in.

VIGILANCE

KEYNOTES OF

Harvey

FABRICATION

G. A. HARVEY & CO. (LONDON) LTD., Woolwich Road, London, S.E.7. Telephone: GREenwich 3232 (22 lines)

HC/HT/4

AVO INSTRUMENTATION

D.C. Amplifiers

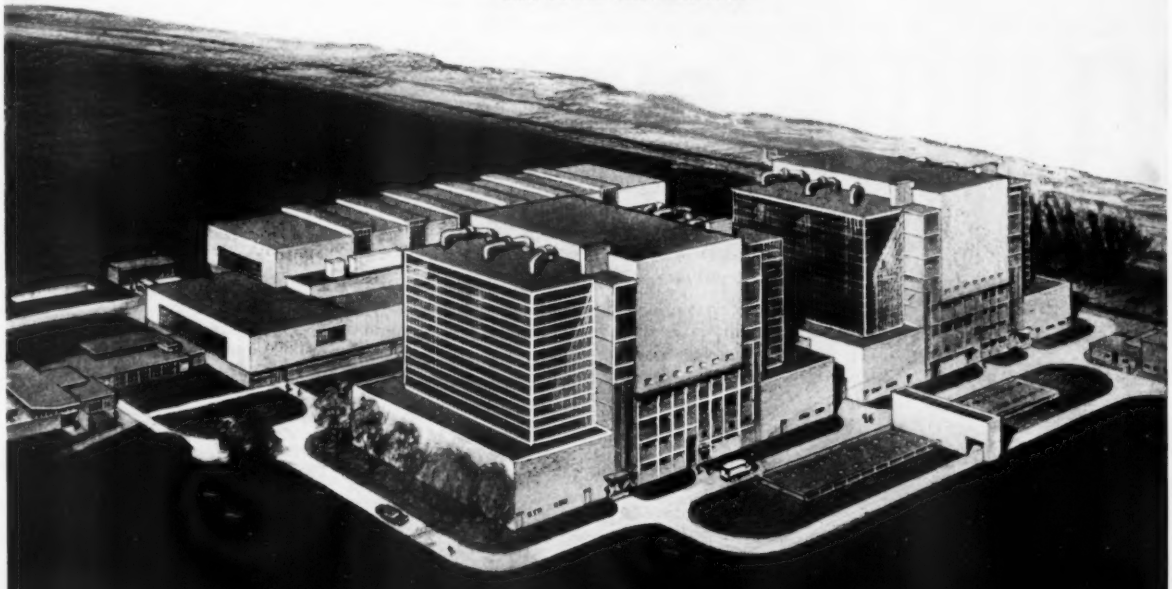
Radiation Monitors

Valve Voltmeters

Multi-range Testmeters

Valve Testers

and other electronic and nucleonic instruments.



BRADWELL NUCLEAR POWER STATION
now under construction for the
Central Electricity Generating Board.

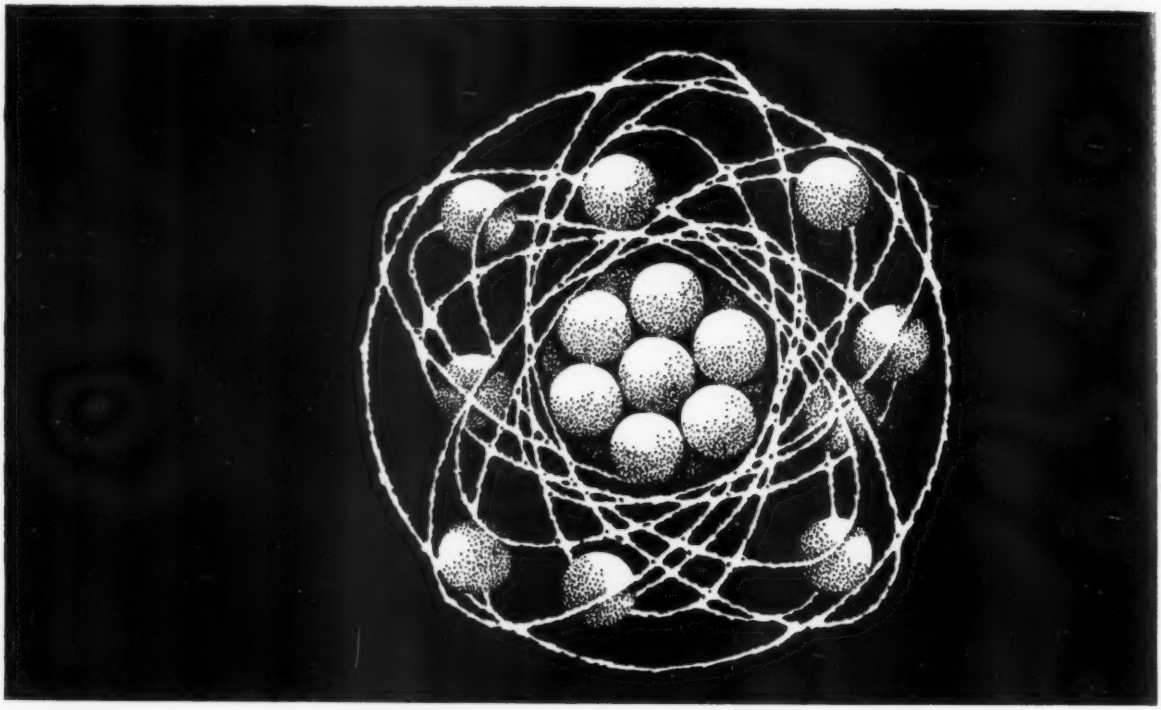
AVO LTD AVOCET HOUSE · 92-96 VAUXHALL BRIDGE ROAD · LONDON · S.W.1

Telephone: VICtoria 3404 (12 lines) *Cables: Avocet, Sowest, London*

— manufacturers of Electronic Instruments since 1923

Illustration by courtesy of The Nuclear Power Plant Co. Ltd.

Tick **No 33** on reply card for further details



Main CO_2 Duct Isolating Valve for Nuclear Reactor Power Plants for working pressures of 10 kg/cm² and 400° C.

E R H A R D

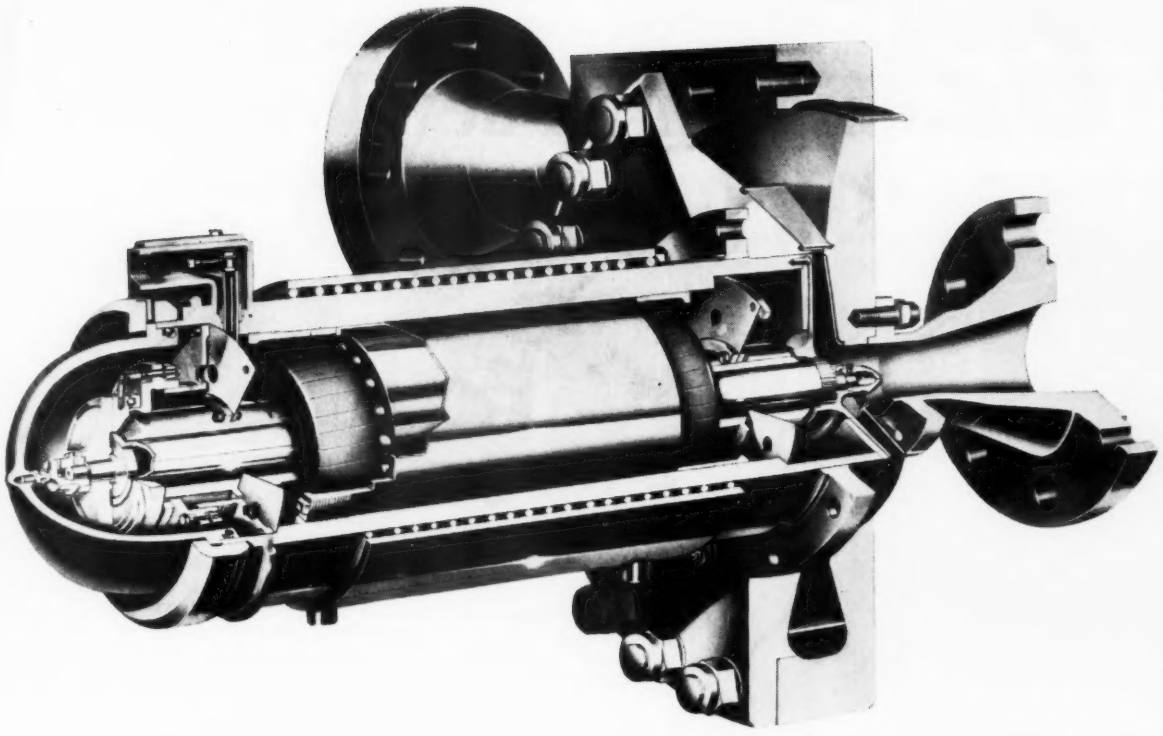
ABSPERRKLAPPEN (Pat. throughout the world)

The design of the ERHARD-Absperrklappen is not limited to the aforementioned temperatures and pressures, and we are in a position to manufacture valves in order to meet the severest temperature and pressure conditions arising in nuclear reactor power plants.

External means are used in order to urge the disc sealing ring on to or away from the valve seat for closing or opening the valve. Operation can be effected according to requirements by hand, electric, pneumatic and hydraulic means.

JOHANNES ERHARD H. WALDENMAIER ERBEN

Süddeutsche Armaturenfabrik Heidenheim an der Brenz Western-Germany



ARMSTRONG SIDDELEY

HAVE DESIGNED A RANGE OF GAS BEARING COMPRESSORS CAPABLE OF HANDLING GASES UP TO...

2,000 psi and 700°C

with input powers up to 2,000 hp.
They have many advantages

They are:

Free from lubricant contamination

Totally enclosed needing no mechanical seals

Practically maintenance free

Capable of operating over a wide range of temperatures and pressures

ARMSTRONG SIDDELEY MOTORS Coventry · England

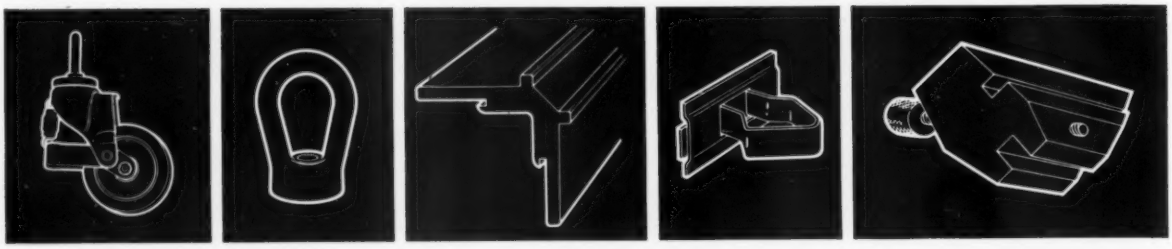
ENGINE BUILDERS TO THE WORLD

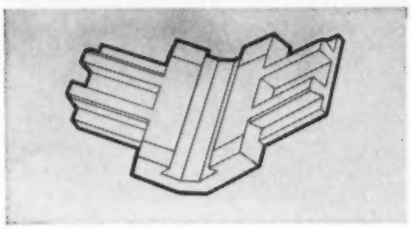
MEMBER OF THE HAWKER SIDDELEY GROUP

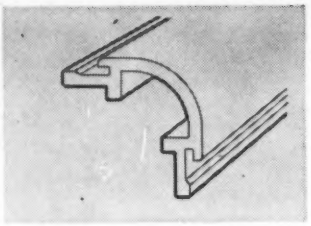
Tick **No 35** on reply card for further details

62 big Imlok developments

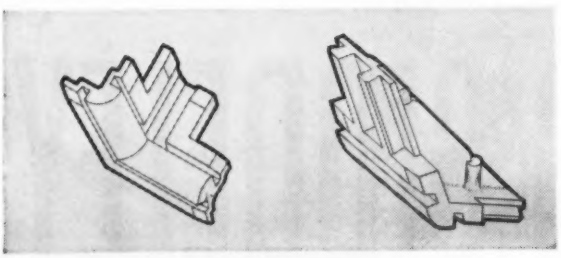
TO SAVE YOU MONEY ON CASE CONSTRUCTION!

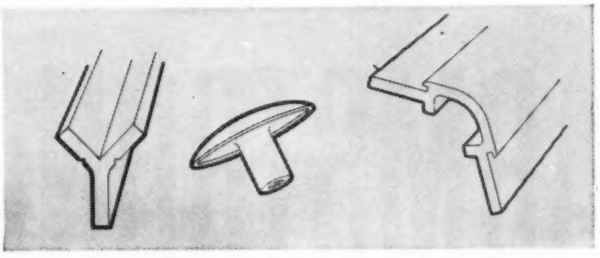


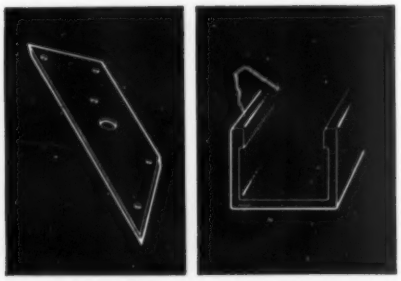




IMLOK—the unique cabinet construction system—now offers designers and engineers even more possibilities than before. Fifty-six new parts have been added to the already wide range of precision-made corner connectors, extrusions and accessories, and you can now buy Imlok in six different stages of manufacture. It means more versatility . . . more scope in case and cabinet design. The Imlok system is ideal for both prototype and production work

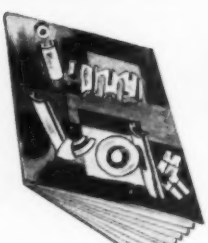






· New 36-Page Imlok Manual

now available, includes illustrations and specifications of all Imlok parts, colour photographs of many cabinet and console designs built in Imlok, as well as new Imlok uses. Send now for free copy



56 new parts

The addition of new connectors and extrusions means you can now have external or internal angles from 22½° to 90°. The new range also includes strengthening extrusions for extra heavy-duty structures, fashion trims, door pulls, castors, and many more. Full list on request

IMLOK

6 ways to buy

1. As individual connectors and with extrusions in 12ft. lengths. **2.** With connectors pre-drilled ready for assembly with self-tapping screws. **3.** With pre-drilled connectors and with extrusions custom-cut by Imhofs to your lengths and mitred. **4.** As a complete framework, ready for fitting with your own panels. **5.** As a complete structure with panels, but unpainted. **6.** As a complete structure, fully finished

Alfred Imhof Ltd., Dept. N4 Ashley Works, Cowley Mill Road, Uxbridge, Middx. Uxbridge 6231

Export & London Showrooms: 112-116 New Oxford St, WC1: Museum 7878

IMHOFS AGENTS OVERSEAS

AUSTRALIA Aladdin Industries (Pty) Ltd, Stanmore NSW
BELGIUM Rogelec, Ghent
CANADA Measurement Engineering Ltd, Arnprior
DENMARK Tage Schouboe, Copenhagen N
FINLAND Oy Scienta Ab, Helsinki
HOLLAND J.Th. van Reijsen, Delft
ITALY Prodel SPA, Milan
NEW ZEALAND Imarex Ltd, Auckland C3
NORWAY Birger Christensen, Oslo
SWEDEN Elektronlund AB, Malmo C
SWITZERLAND Walter Blum, Zurich 2/39
U.S.A. Bud Radio Inc, Cleveland 3, Ohio
BRIT. GUIANA British Caribbean Agencies Ltd, Georgetown, Demerara

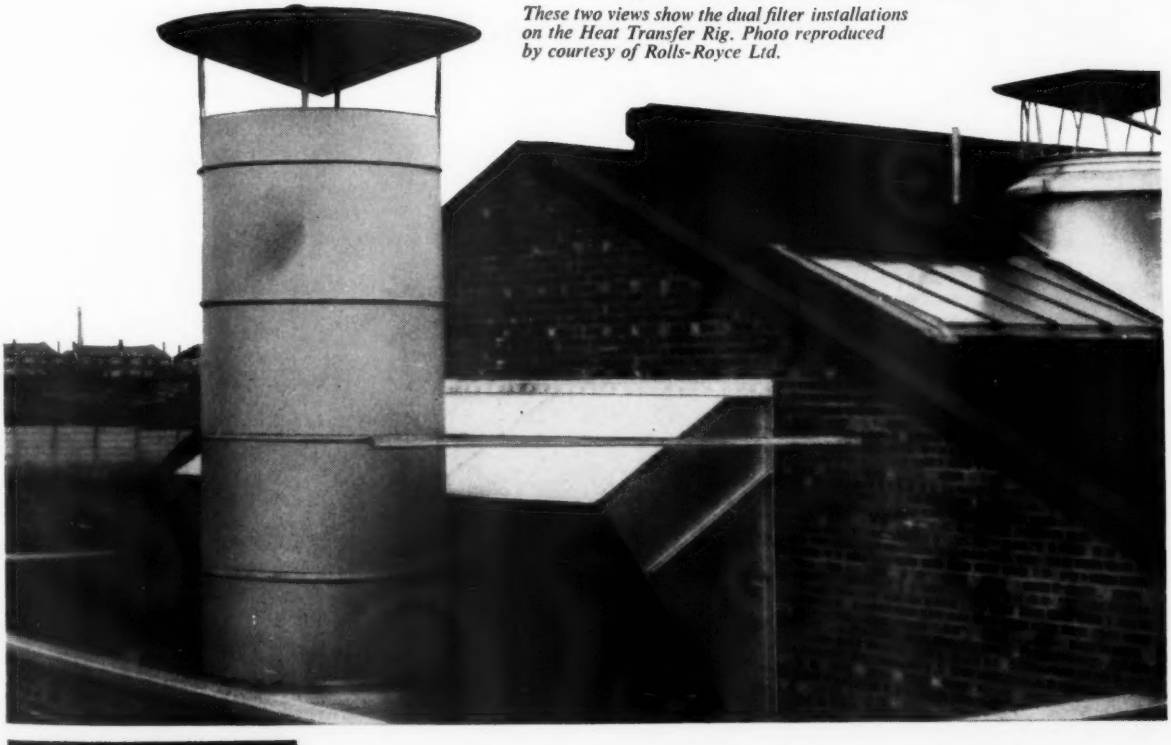
ROLLS-ROYCE

instal VOKES K.600 KOMPAKS
in their new Heat Transfer Rig.

The new Heat Transfer Rig at Rolls-Royce Limited is playing a major part in their nuclear research programme, and to ensure maximum protection our K.600 Kompak filters were chosen for the air intake filtration. The Kompak, tested in accordance with BRITISH STANDARD 2831, showed the following efficiencies with the highly penetrating test dusts specified :—Against Aloxite 50—95%. Against Aloxite 225—93%. Simple replacement of the filtering medium, low first cost and a GUARANTEED performance makes the Kompak your best buy. Full details available on request.

*** When specifying your filtration requirements, we strongly recommend that you request test information against B.S.S.2831.**

These two views show the dual filter installations on the Heat Transfer Rig. Photo reproduced by courtesy of Rolls-Royce Ltd.



VOKES

VOKES LIMITED • GUILDFORD • SURREY

Tel: Guildford 62861 (6 lines). *Grams & Cables: Vokesacess, Guildford, Telex. Telex: 13-535 Vokesacess, Gfd.*

Vokes Australia Pty. Ltd., Sydney. Represented throughout the World.

Air and Gas Filters for Chemical, Nuclear Energy, Oil Refinery, and Pharmaceutical applications etc; Air conditioning filters; Compressed air pipe line filters; Air, Oil, and Fuel filters for Diesel, Gas Turbine, and other i/c engines; Hydraulic filters; Silencers for Engines, Fans and Blowers; High efficiency Multi Cyclones.

V325

* tailor-made to each job!

MULTIRAIL
fabricated steel handrail standards

MULTIRAIL fabricated steel handrail standards have proved to be as rigid as the solid forged type, with the advantages of four ferrules enabling vacant ferrules to be used in carrying power lines, air and gas pipes, etc.

"SAFETREAD" FLOORING IS

welded for extra strength

Tailor-made and not just cut to fit, 'Safetread' flooring is no dearer to specify than ordinary steel flooring, but provides maximum strength with minimum of materials; non-skid surface; 82% light and air penetration; a neat-fitting, clean appearance.

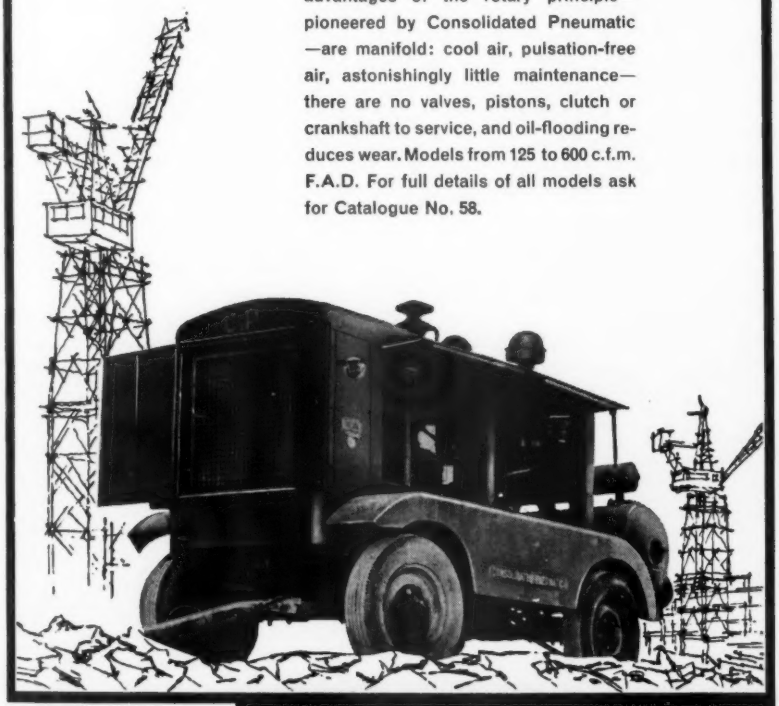
SAFETREAD
WELDED FLOORING

Write for detailed literature to:

Allan Kennedy & CO. LTD.
MARITIME STREET · STOCKTON-ON-TEES

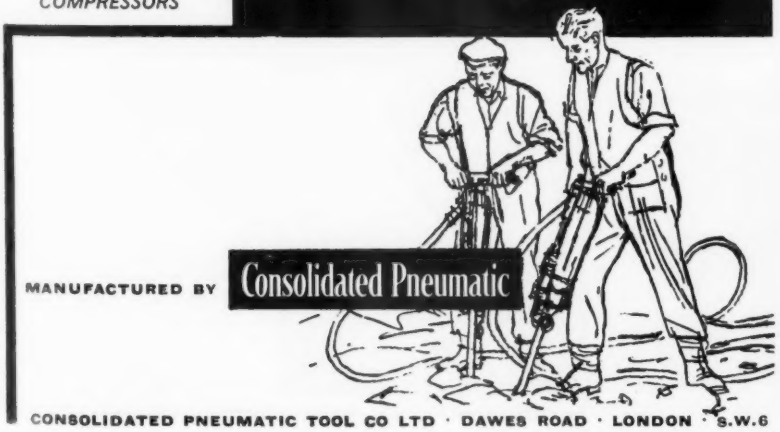
Tel: Stockton 65464 (4 lines). Grams: Grating, Stockton-on-Tees. Also at 207 Victoria Street, London, S.W.1

THIS is the compressor that costs less to run: the Power Vane Rotary. The advantages of the rotary principle—pioneered by Consolidated Pneumatic—are manifold: cool air, pulsation-free air, astonishingly little maintenance—there are no valves, pistons, clutch or crankshaft to service, and oil-flooding reduces wear. Models from 125 to 600 c.f.m. F.A.D. For full details of all models ask for Catalogue No. 58.



POWER VANE ROTARY COMPRESSORS

Cost less to run



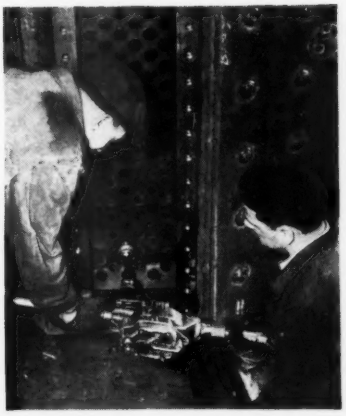
MANUFACTURED BY Consolidated Pneumatic

CONSOLIDATED PNEUMATIC TOOL CO LTD · DAWES ROAD · LONDON · S.W.6

CP184

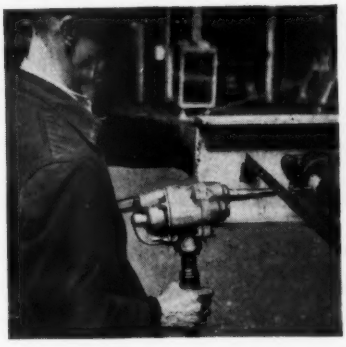
CP Air Tools for Tube Expanding

Sheer power applied at a slow, steady speed of rotation is the secret of successful tube expanding and it is this characteristic of CP air tools at low r.p.m. which has resulted in their extensive use for this class of work. Our picture shows the model 327 in operation and this tool can be supplied in six speeds from 700 to 55 r.p.m. The CP range includes a model designed for extra heavy duty, the CP 3500 running at 40 or 20 r.p.m. Ask for literature describing this range of equipment.

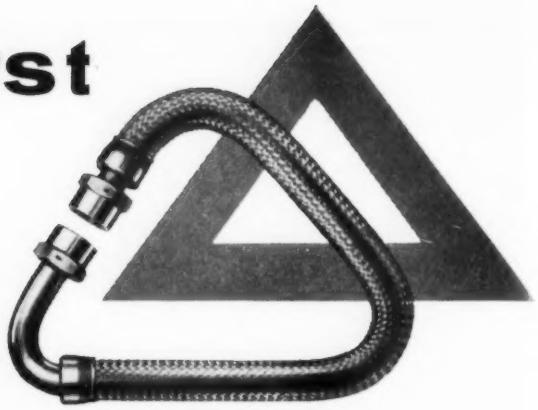


Even the simple job of drilling needs the right tool

Convenience, speed and flexible power are the attributes of the pneumatic drill, but in the CP range the advantages go even higher. With nearly 40 different models and speeds, ranging from $\frac{3}{16}$″ to 3″ capacity, there is definitely a CP tool for any type of drilling operation. All these are described in detail in catalogue 50C available on request.



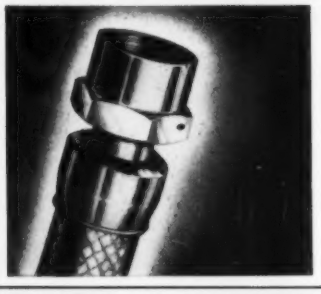
safety first



AVICA-FLEX

BELLOWS

(*including precision barometric units*, with closely controlled spring rate tolerances). For use in gas and fluid ducting systems for control of expansion or contraction, and to allow for misalignment. Other uses include shaft seals and glands. Available in stainless steel and other metals.



AVICA-FLEX

STAINLESS STEEL FLEXIBLE PIPE ASSEMBLIES

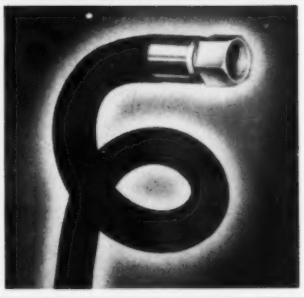
For conveying gases and corrosive fluids at temperatures from −196°C to as high as 450°C. Available from $\frac{1}{8}$" up to 4" diameter.

specify **AVICA** flexible assemblies and components

Where pressures or temperatures reach unusual extremes and vibration may be severe, take no chances—insist on AVICA pipe assemblies and components. Tested and proved by 20 years of service and used by the U.K.A.E.A. and throughout the nuclear engineering field, AVICA products are renowned for absolute dependability. Any problem of piping design or installation can safely be entrusted to Avica engineers.

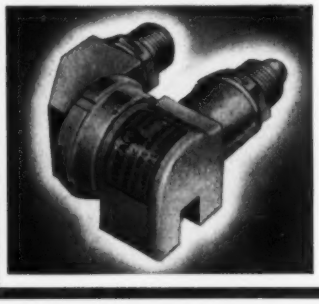
RIGID TUBE COUPLINGS

With mechanically attached V Flange or bolted flange connections. No welding. No brazing. Leak-proof. Pressure tight. Will withstand extremes of temperature and vibration.



SYNTHETIC RUBBER FLEXIBLE PIPE ASSEMBLIES

Used to carry petrol, oil, air, steam, hydraulic fluids, for machine tools, hydraulic presses, mining equipment, at pressures up to 3,000 p.s.i. Size range $\frac{1}{4}$"—2". Temperature range −40°C to 160°C.



SWIVEL PIPE COUPLINGS

To provide rotary or angular movement in rigid or flexible pipe systems. In pipe sizes up to 1" for pressures up to 4,000 p.s.i.

SUPPORT CLAMPS

To hold piping and electrical cables. The rubber cushion absorbs vibration, can be renewed when worn or perished.

Illustrated leaflets describing the full range of AVICA products are available on request. Please write for those that interest you.

IGNITION HARNESS

Electrical wiring protected by rigid or flexible conduit from heat, oil, moisture and vibration.

AVICA

AVICA EQUIPMENT LIMITED

MARK ROAD, HEMEL HEMPSTEAD, HERTS

Telephone: Boxmoor 4711 Cables: Avica Hemel Hempstead.

WIN THE BATTLE OF THE BURR..

..BY USING **Morrisflex Hammond**

BUILT UNDER LICENCE FROM
HAMMOND MACHINERY BUILDERS INC. U.S.A.

B. O. MORRIS LTD. • BRITON ROAD • COVENTRY
Telephone: 53333 (PBX) Telegrams: MORISFLEX, COVENTRY.

Tick **No 41** on reply card for further details

The **EXPERIENCE . . .**

. . . gained in supplying
Drop Forgings
in special creep-resisting
Alloy Steels
and nickel-based alloys
for gas turbines
since the first Whittle engine,
is at the disposal of
Designers and Metallurgists
in every industry.

A Main Supplier
of Drop Forgings
to those industries
with problems of
high stresses
and high temperatures ;
we are specialists in the
fields of

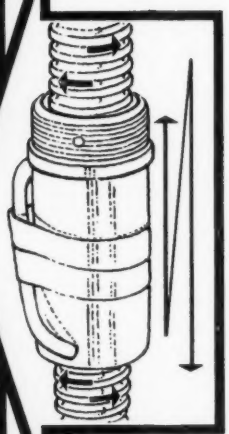
ASTRONAUTICS
and NUCLEAR
ENERGY

A 16mm Colour Film with sound commentary, entitled "Drop Forgings in Alloy Steels," is available on request.

FIRTH-DERIHON
SHEFFIELD & DARLEY DALE

THE FIRTH-DERIHON STAMPINGS LTD. · SHEFFIELD · ENGLAND

Armstrong Siddeley provide a comprehensive range of high precision recirculating ball and lead screws and splines for universal applications.



HIGH EFFICIENCY

BACK-LASH ELIMINATION

LONG LIFE

LOW MAINTENANCE FACTOR

Up to 80% reduction in power can be achieved for actuation compared with conventional methods.
Ability to run at high temperatures with and without lubrication.
Over 2,700 applications already established in all fields of engineering.
Complete technical and manufacturing co-operation with Beaver Precision Products Inc., Detroit.

ARMSTRONG SIDDELEY MOTORS
COVENTRY · ENGLAND

MEMBER OF THE HAWKER SIDDELEY GROUP

Tick **No 43** on reply card for further details

By kind permission of the N.C.B. North Eastern Division

PROTECT WITH EVOKOTE

EPIKOTE RESIN BASED PAINTS

Above:—Ammonium Sulphate plant at Manvers Main Coking Plant, treated with Evokote Type 10
Below:—Maplewood floor treated with Evokote Type 20 at the works of John Mackintosh & Sons Ltd., Halifax

Four air drying grades supplied to combat all types of aggressive and corrosive conditions.

CORROSION EXHIBITION STAND No. 8 April 27–30

A PRODUCT OF EVODE OF STAFFORD

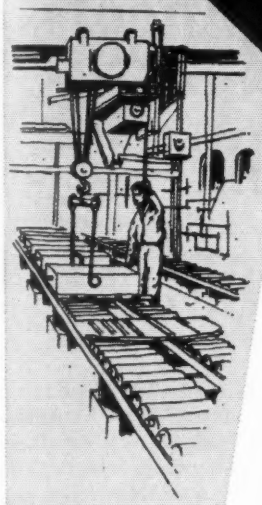
Manufacturers of BITUGEL, EVODYNE and EVO-LED paints

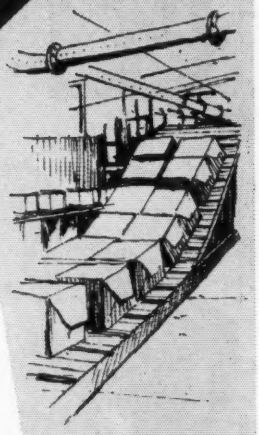
✳ **SEND FOR LITERATURE** EVODE LTD., (PAINTS DIVISION) STAFFORD. Telephone: 2241-5

London Office: 82 VICTORIA STREET, S.W.1. Telephone: ABBey 4622-3

M-W.115R

PATERSON HUGHES
ENGINEERING COMPANY LIMITED

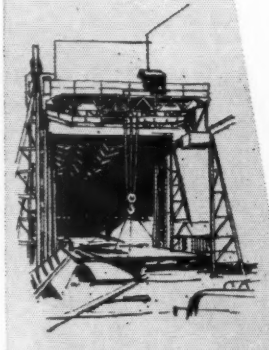




UNITED DIVISIONS

The united efforts of specialist engineering divisions concentrated upon particular aspects of mechanical handling, enable Paterson Hughes to plan and design integrated handling and production schemes specially suited to particular requirements. Large design and manufacturing resources, and first-class installation and maintenance service ensure that Paterson Hughes mechanical handling equipment gives complete and continued satisfaction. Engineers are always available to discuss your problems.

MECHANICAL HANDLING ENGINEERS & CRANE MAKERS



FOUNDRY DIVISION

The Foundry Division has long experience in the foundry industry. Many examples of Paterson Hughes pouring runways, conveyor systems, complete sand handling plants, cupola charging plants, casting cooling conveyors, are at work throughout the industry today.

CRANE DIVISION

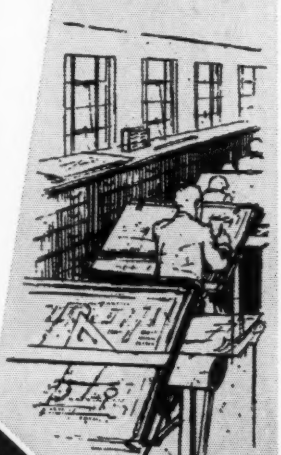
Paterson Hughes electric overhead travelling cranes up to 100 tons capacity are manufactured in the modern crane works in Glasgow. Competitive prices and exclusive design features have put Paterson Hughes cranes in the forefront of the industry.

INDUSTRIAL HANDLING DIVISION

Conveyor and elevator systems of all types for the handling of bulk materials, packaged goods and unit articles are undertaken for all industries. Paterson Hughes conveyor systems have ensured higher and smoother production flow in many well-known factories.

DESIGN FACILITIES

Design capacity is always available to assist clients not only in the planning and layout of mechanical handling systems, but also for the development of new projects and new machines. Strategically placed area offices enable close liaison to be maintained.



BIRMINGHAM
3 Highfield Road
Edgbaston Birmingham 15
Phone: Edgbaston 2957-8

GLASGOW
Wyndford Works
Maryhill Glasgow
Phone: Maryhill 2172-4

SOUTH AFRICA—Paterson Hughes Engineering SA (PTY) Ltd PO Box 811 Johannesburg

LONDON—Bedford House Bedford Street London WC2 Phone: Temple Bar 7274-6

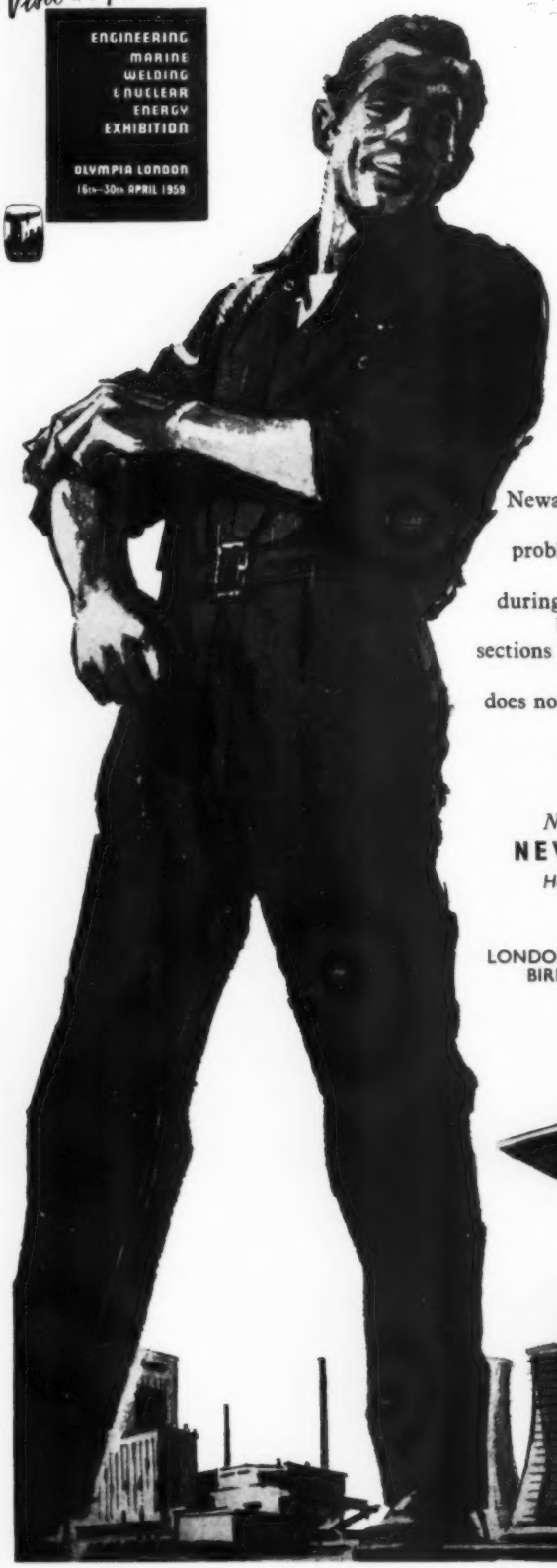
P.2114

Tick **No 45** on reply card for further details

Visit the Great

ENGINEERING
MARINE
WELDING
& NUCLEAR
ENERGY
EXHIBITION

OLYMPIA LONDON
16th–30th APRIL 1959



give NEWTHERM your toughest insulation assignment

Newalls (Reg'd Brand) NEWTHERM Calcium Silicate insulation is the finest answer yet to many of industry's heat insulation problems. *Strong and rigid,* Newtherm withstands rough handling in transit and erection, with negligible breakages even during transport to remote sites. *Exceptionally light,* Newtherm can be applied in difficult situations with ease — even the largest sections being manageable in one hand. *Moisture resistant,* Newtherm retains much of its strength even when immersed in water, does not deform, and quickly dries, leaving its strength and thermal efficiency unimpaired. *Easily applied,* Newtherm offers a smooth surface and straight edges for speedy fitting, and is available in many standard sizes for immediate application.

NEWTHERM Calcium Silicate is manufactured solely by

NEWALLS INSULATION COMPANY LIMITED

Head Office : **WASHINGTON, CO. DURHAM, ENGLAND**

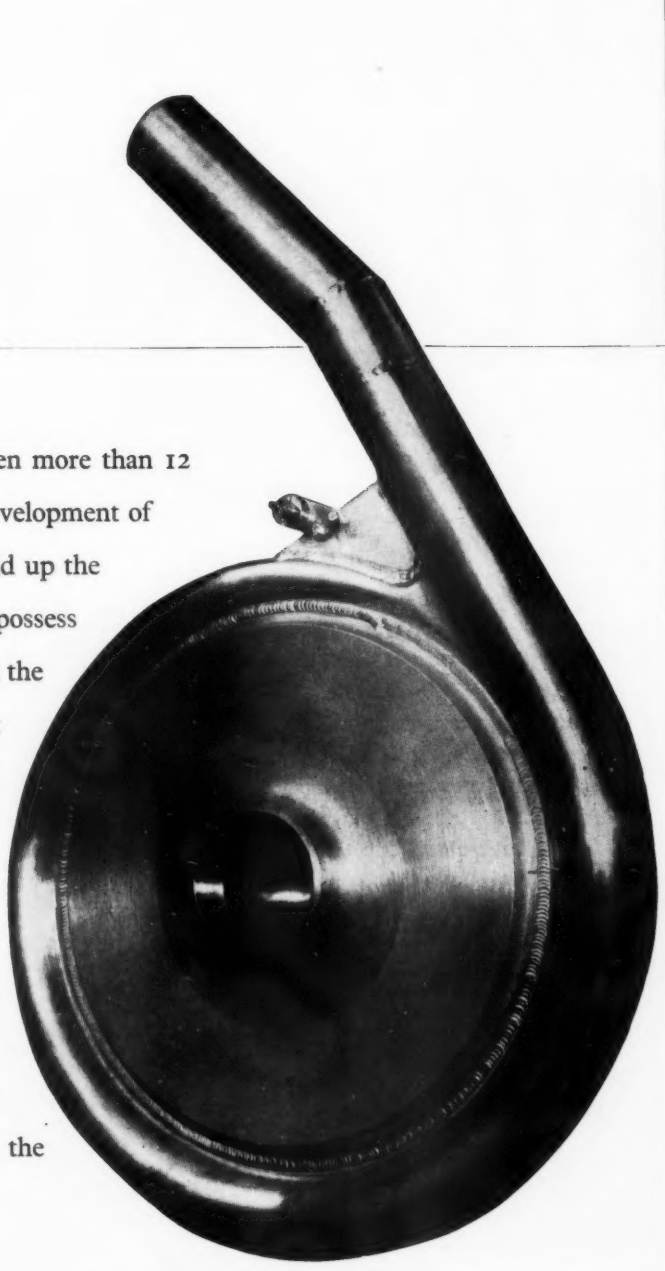
A member of the TURNER & NEWALL ORGANISATION

Offices and Depots at :
LONDON, GLASGOW, MANCHESTER, NEWCASTLE UPON TYNE, BIRMINGHAM, BELFAST, DUBLIN, BRISTOL and CARDIFF.

Agents and vendors in most markets abroad.

Shaping the Future

Skill doesn't come easily. It has taken more than 12 years of close association with the development of Atomic Energy for Marstons to build up the specialized technical knowledge they possess in this field. Marston Excelsior, from the start, have been among the foremost suppliers of specialized equipment to the U.K.A.E.A. — plate type fuel elements for the research reactors Dido, Lido, and Dimple; gas coolers for Calder Hall, equipment of various kinds for ancillary plants. It is this past experience that is helping Marstons to shape the future with such precision.



MARSTON EXCELSIOR LIMITED

Fordhouses, Wolverhampton

(A subsidiary of Imperial Chemical Industries Limited)

INVOLUTE COMPRESSOR CASING

(approximate diameter 30″, overall thickness 5″) made in two half-pressings from Kynal P5, Argon Arc welded. In the centre, fully machined vanes made from aluminium castings are sandwiched between the centre plates.

MAR 234

Tick **No 47** on reply card for further details

There's no excuse for
CORROSION

Many thousands of tons of steel are lost through corrosion every year and much of this can be saved. *There is a remedy.*
"Superlative" Metal Primer provides a positive protection against corrosion for all ferrous metals. It is quicker and easier to apply than conventional Lead Coatings and is infinitely cheaper. But, as *efficiency* is the factor that matters, and "Superlative" is so economical and so effective, it pays to specify

"Superlative"
METAL PRIMER

Kills **CORROSION AT THE SOURCE**

Our Techniservice will gladly answer all enquiries.

BRITISH PAINTS LIMITED

Portland Road, Newcastle upon Tyne, 2.
Crewe House, Curzon Street, London, W.1., 31, Wapping, Liverpool, 1.

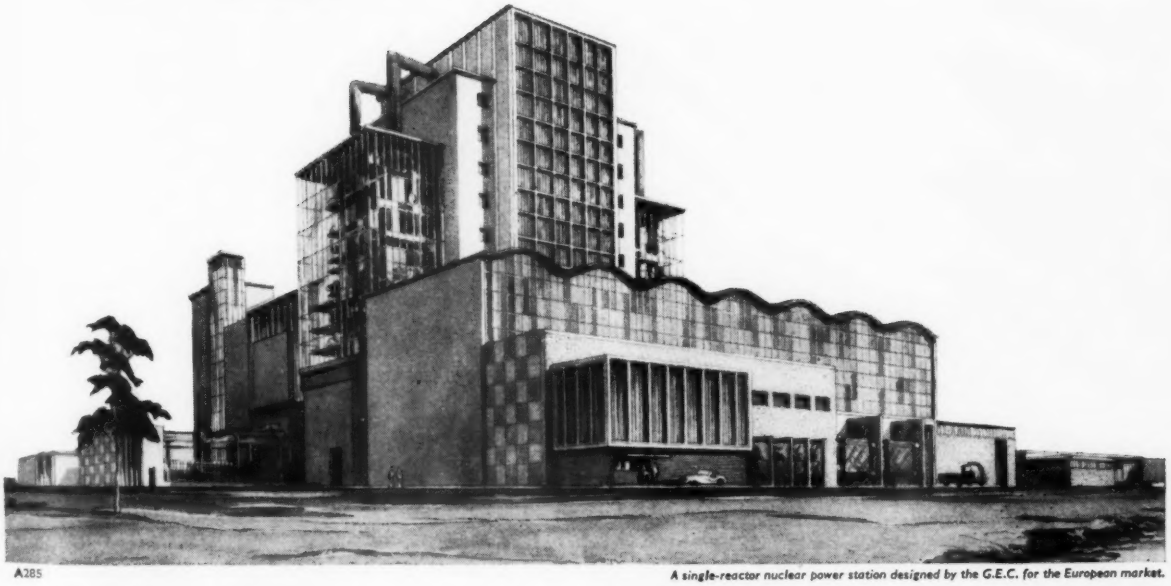
BY APPOINTMENT TO HER MAJESTY QUEEN ELIZABETH II MANUFACTURERS OF PAINT BRITISH PAINTS LIMITED

BELFAST · BIRMINGHAM · BRISTOL · CARDIFF · GLASGOW · LEEDS · MANCHESTER · NORWICH · PLYMOUTH
SHEFFIELD · SOUTHAMPTON · SWANSEA AND ALL PRINCIPAL TOWNS

40 to 400 MW per reactor

Nuclear power stations with electrical outputs ranging from 40-400 MW per reactor can be designed and built by the G.E.C. in any part of the world. The reactors, which are based on the well-established Calder Hall design, have been made possible by intensive research and development work at the Erith headquarters of the G.E.C. Atomic Energy Division.

G.E.C. ATOMIC ENERGY DIVISION



A285

A single-reactor nuclear power station designed by the G.E.C. for the European market.

THE GENERAL ELECTRIC COMPANY LIMITED · ERITH · KENT · ENGLAND

Tick **No 49** on reply card for further details

another problem solved with UNISTRUT

INSTALLING INSTRUMENTATION AT AUTOMATED "SEGAS" OIL GASIFICATION PLANT

Three men and a computer control the production of 20 million cubic feet a day of town gas at Britain's first large-scale oil gasification plant. South Eastern Gas Board engineers faced an unusually complex problem in installing the instrumentation network essential for such a high degree of automation.

Unistrut steel channel framing and a pipe/cable clamp from the comprehensive range of Unistrut fittings gave the satisfactory solution, with the following advantages . . .

Accurate routing

9½ miles of service pipes—hydraulic, air, electric and instrumentation—run from all parts of the £2½ million plant to the central control room traversing a 253 ft. long covered cable bridge with a drop of 20 ft. at each end. Each pipe has to be precisely located in relation to the control panel and computer and any slight positional errors in erection would be considerably magnified over runs of up to 500 ft. By using Unistrut, in which the position of every fitting is infinitely adjustable before and after attachment, accurate positioning was made possible.

Ease of access

The pipes run through the cable bridge on five 8 ft. high Unistrut racks, four of which are double banked, the five rows of vertical supports being connected at the top to complete the box section and their bases slot-clamped to a horizontal Unistrut channel to allow for heat expansion. Further Unistrut framing carries the pipes to the control room floor where they are attached by clips to Unistrut channels.

In a plan of this type it is of course essential that all servicing be carried out with minimum delay. A false floor of Unistrut beams on which are laid 5′ x 2′ nominal size panels of rubber covered plywood gives immediate access.

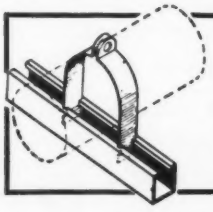
Exterior use

Galvanised Unistrut, available as an alternative to the standard stove-enamelled finish, was used for the trusses supporting the pipes in the open between the gasification units and cable bridge.

Erection economies

Welding and drilling, which would have represented a considerable expense in using conventional support methods for a project of this scale, were eliminated by Unistrut's rapid, self-locating nut assembly. This standardised method was used to form all the framing, in which 10,600 feet of Unistrut were used, and adds to the basic strength of the cold-rolled steel channel by completing a rigid box-section. Further economies were realised in running the pipes, by using the clip-in fitting shown below, which obviated the need to mark out in advance the precise position of each point of attachment.

This application illustrates some of the on-site advantages of the Unistrut steel-channel framing system, including the fast and economical erection of rigid structures and rapid attachment of services. It cannot however indicate the full scope of the system, which includes a full range of components for supporting every type of service. For further information, please write to the address below.



The Unistrut clamp employed throughout this installation typifies the economy of material and effort derived from the Unistrut's special channel section. The two parts of the clamp are located by cut-out lugs against the inside of the channel, so that a single screw and nut is all that is necessary to fasten or release the assembly. (For larger pipes, flanged clamps or rollers are used, bolted to self-locating nuts inserted at the desired point of the continuous-entry channel.)

UNISTRUT

STEEL CHANNEL FRAMING SYSTEM

Please write for technical information to
Unistrut Division of Sankey-Sheldon Ltd. *A member of the Guest, Keen and Nettlefolds Group of Companies.*
43-45 Broadwater Road, Welwyn Garden City, Herts. Telephone: Welwyn Garden City 5406.
UNI 11062

FANS and BLOWERS

FOR THIS ATOM AGE

KEEPING PACE with the demands of successive atomic projects, 'Tornado' fan engineering equipment is today assisting the exacting work in UKAEA establishments. In addition to equipment at Aldermaston, Capenhurst, Dounreay, Foulness, Harwell, Risley, Springfields and Windscale, other Keith Blackman fans and blowers are being used experimentally elsewhere. The demands of the atomic industry are often unusual but years of experience and unrivalled facilities have made Keith Blackman "specialists in the unusual."

If the problem involves the handling of air or other gases, contact

Keith Blackman

Fan makers since 1883

KEITH BLACKMAN LTD · MILL MEAD ROAD · LONDON · N17

or at Manchester · Newcastle · Birmingham · Leeds · Glasgow · Leicester · Bristol

'Tornado' equipment includes: CO_2 COOLANT BLOWERS and HEAT EXCHANGER COOLING FANS. FANS FOR VENTILATION, DUST REMOVAL and HIGH TEMPERATURE EXTRACTION · BLOWERS FOR GAS BOOSTING, DRY SCRUBBERS and VESSEL VENTILATION. Also AIR SAMPLING COMPRESSORS, AIR FLOW CONTROL UNITS, BACK PRESSURE VALVES, STEEL FABRICATIONS and the SHOT CLEANING of HEAT EXCHANGERS.

T.A. 11962/843

pH and Quality Control

In many processes and undertakings, control of the pH factor plays an essential part in determining quality and increasing efficiency. Protection from corrosion or pollution, conservation of reagents and considerable reductions in waste are among the advantages gained by users of KENT equipment for pH measurement and control.

The recently introduced *Universal* pH miniature primary elements for flow-line and immersion (illustrated), which use a glass electrode as the pH-responsive element, are further examples of KENT progress in "conventional" applications. Further information about these miniature primary elements is given in Publication NP158, obtainable on request.

NEW miniature primary element for flow-line and immersion

In the nuclear energy field KENT supplied the first industrial pH equipment for heavy water (pD). Here, because of the need to maintain a high degree of D_2O purity in the reactor circuit, an economical but efficient bleed-off system is employed, in which the minute sample flow of costly D_2O is returned from the primary cell to the main circuit after purification. Time-lags which would normally result from the use of such a small sample are successfully overcome by incorporating a specially designed electrode chamber.

KENT

for the control of variables

GEORGE KENT LIMITED · LUTON · BEDFORDSHIRE · ENGLAND

Factories, Subsidiary Companies, and Branch Offices in

London · Resolven · Hitchin · Toronto · Montreal · Vancouver · Melbourne · Sydney · Johannesburg · Salisbury · Penang · Bangkok · Brussels · Krefeld · Vienna

what are the advantages of SINTOX alumina ceramics?

THE NUCLEAR CERAMIC

VISIT STAND No. 3 ROW AA FIRST FLOOR AT THE ENGINEERING, MARINE, WELDING & NUCLEAR ENERGY EXHIBITION OLYMPIA APRIL 16TH — 30TH

These qualities have led to the use of SINTOX ceramics in many branches of engineering.

For the nuclear engineer a new grade of SINTOX—known as FF1—has been developed. In addition to its other attractive features, nuclear SINTOX has a low cross-section capture combined with compatibility with most materials used in reactor design. It is versatile in the production of a wide range of shapes and sizes and is particularly suitable for insulating parts in control gear and mechanical support members. White in colour, this new ceramic has already taken a leading place in the design and development of components for nuclear reactors.

STAS

For full information write to the
SINTOX TECHNICAL ADVISORY SERVICE, LODGE PLUGS LIMITED, RUGBY.

Having a bearing on **AGR**

Ruston & Hornsby announce that the NFB Gas Bearing Circulator has been selected for installation on the Refuelling Machine of the Advanced Gas Cooled Reactor which is being carried out by the Special Engineering and Nuclear Division of John Brown & Co. Ltd. for the United Kingdom Atomic Energy Authority.

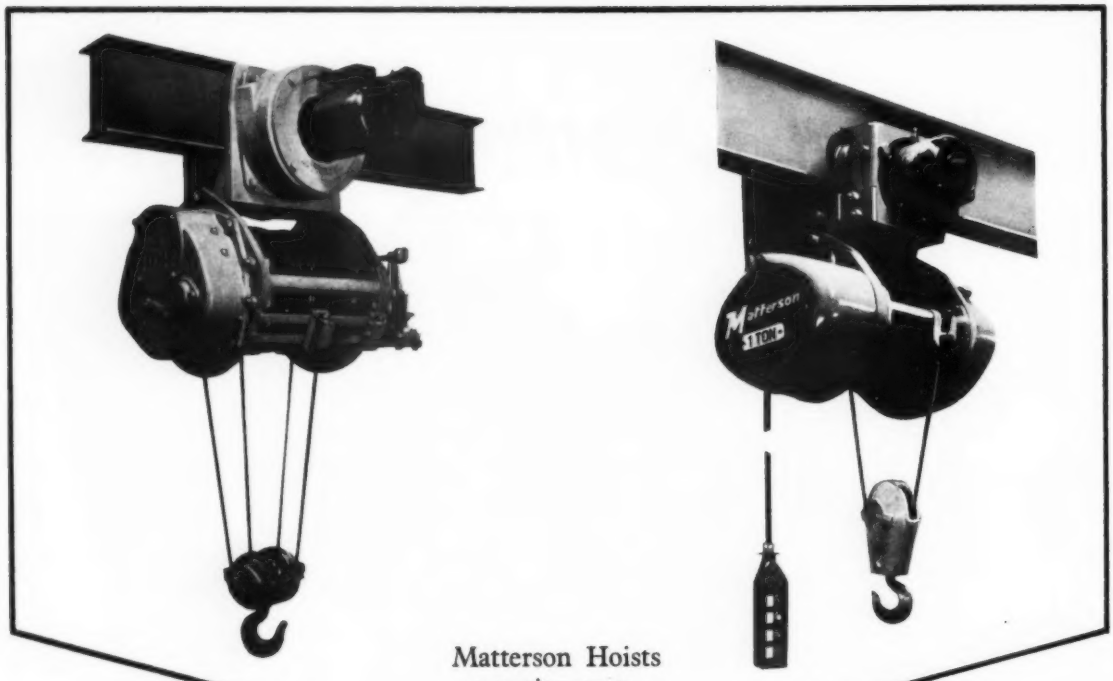
See our exhibit on STAND 9E (Grand Hall) at the Engineering, Marine, Welding and Nuclear Energy Exhibition, Olympia . . . 16-30th April

RUSTON **'NFB' GAS BEARING CIRCULATOR**

RUSTON & HORNSBY LIMITED · NUCLEAR DIVISION · LINCOLN · ENGLAND

Associated with Davey, Paxman & Co. Ltd., Colchester, England.

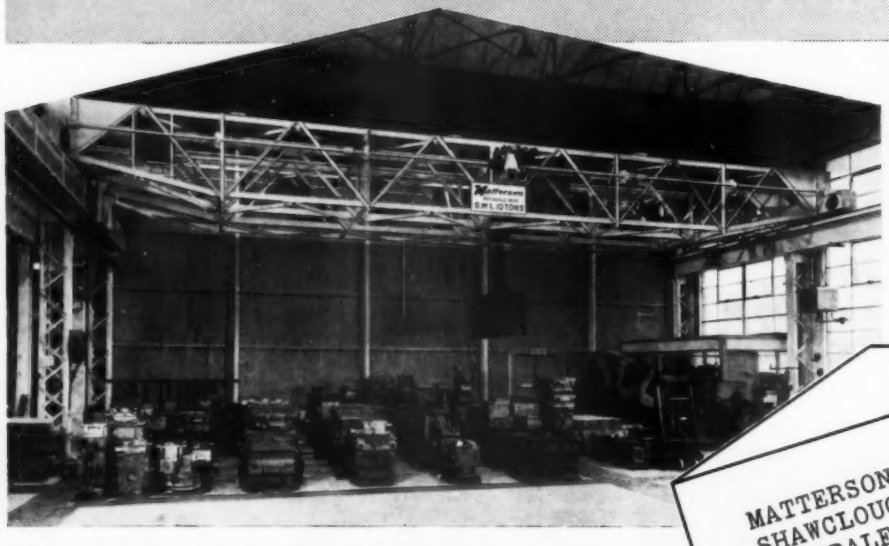
Tick **No 55** on reply card for further details



Matterson Hoists
capacity up to
10 tons

Matterson

THE MODERN NAME FOR CRANES



Quality and service combined with low cost and high performance, in a comprehensive range of truly British Cranes and Hoists—your inevitable choice Matterson the modern name for Cranes.

MATTERSON LIMITED,
SHAWCLOUGH,
ROCHDALE,
LANCASHIRE,

40 Years Service to British Industry

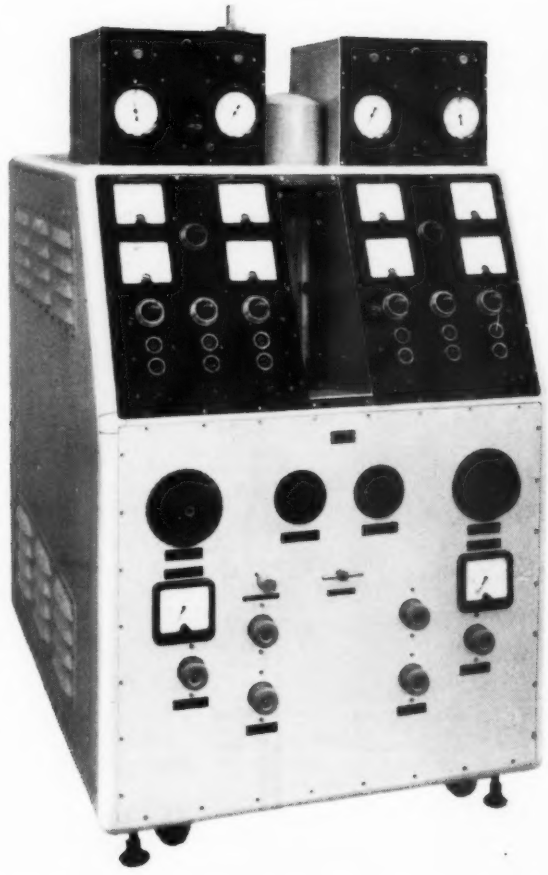
Matterson Cranes capacity up to 50 tons
Comprehensive leaflets giving details and prices of the Matterson range of Cranes and Hoists, are yours for the asking.

Write NOW!

TEL.: ROCHDALE 4932:

P. 2013

Do you require HIGH PURITY Argon?



For the removal of moisture, oxygen and nitrogen. For cleaning up the atmosphere in glove boxes. For welding or for any other application where the need arises to remove one or more of the above impurities.

THE MARK IV SELF-CIRCULATING GAS PURIFIER

Supplied in single or in tandem units for long process work. Fully instrumented. Fully automatic

WESTERN DETAIL
WESTERN WORKS,

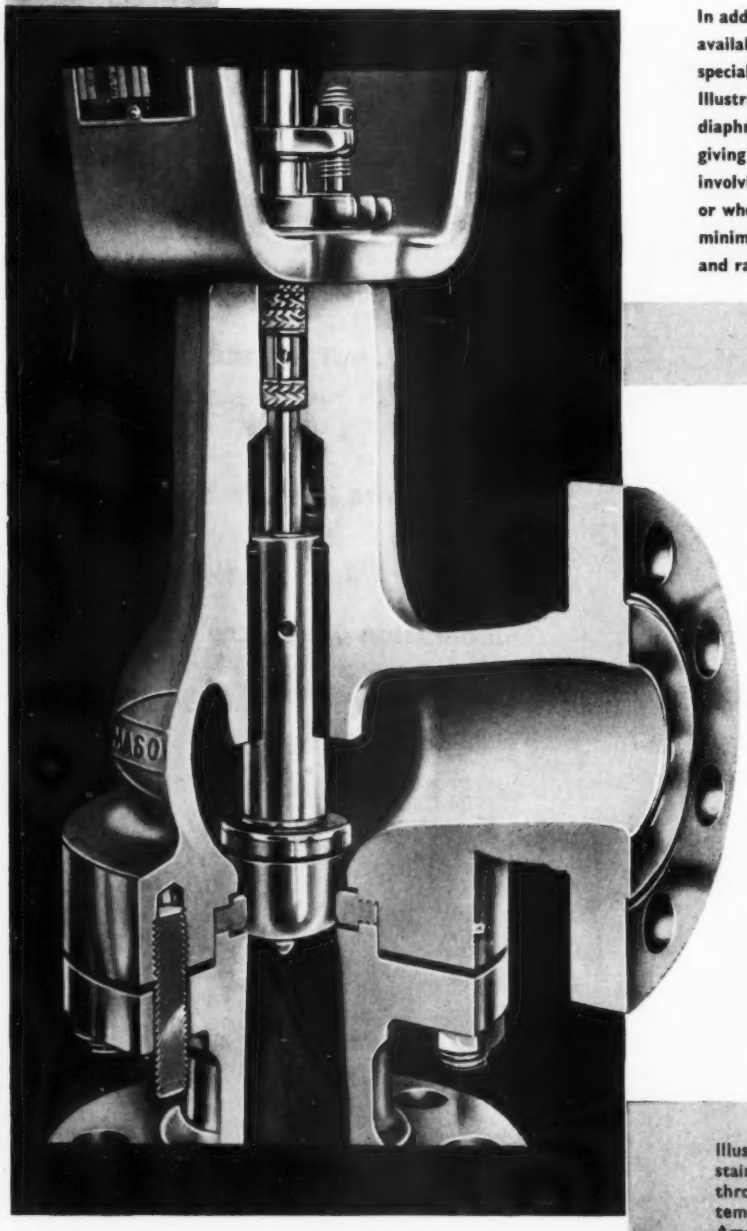
WESTERN DETAIL MANUFACTURERS LTD

MANUFACTURERS LTD
STAPLE HILL, BRISTOL.

Telephone 65-6141/2/3 Telegrams: Aries, Bristol Cables: Aries, Bristol, England

Tick **No 57** on reply card for further details

Special MASONEILAN CONTROL VALVES for special applications



In addition to the Mason Neilan globe type valves we have available other types of Control Valves for more specialised applications involved in process control. Illustrated, left, is one example: type 777 Mason Neilan diaphragm operated Angle Valve, a single-seated type giving a tight shut-off: it is used in varying conditions involving solids in suspension or other erosive applications or where flashing conditions are to be kept to a minimum. Split body construction facilitates easy and rapid maintenance of this valve.

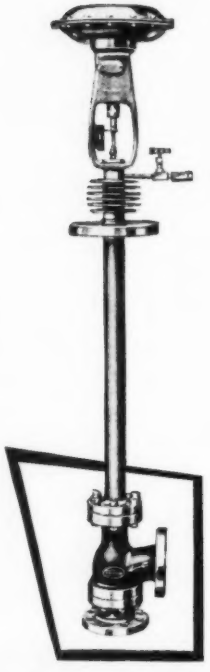
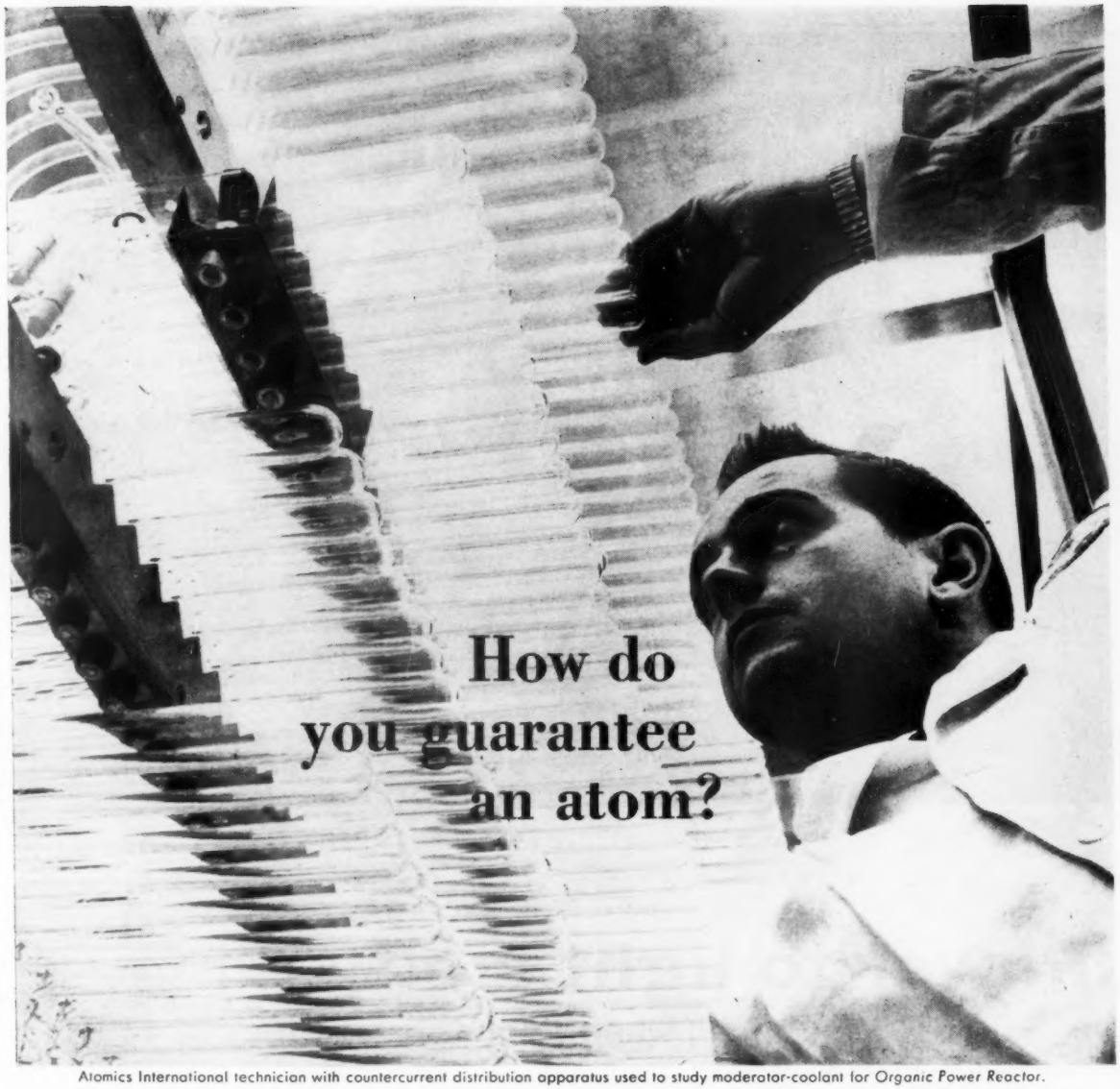


Illustration above shows a special stainless steel Angle Valve supplied for throttling service on very low temperature oxygen gas application. Among other special features it is fitted with extension bonnet and warming fins to prevent loss of "cold" and to prevent icing at the gland.

THE CROSBY VALVE & ENGINEERING CO. LTD.
CROSBY WORKS, EALING ROAD, WEMBLEY, MIDDLESEX
Alperton 2311

CHWR/11



Atomics International technician with countercurrent distribution apparatus used to study moderator-coolant for *Organic Power Reactor.*

Begin with the knowledge of experienced scientists... conduct a seven-year research and development program ...collect a wealth of solid operating experience. Result: GUARANTEED PERFORMANCE of a nuclear power reactor, designed by Atomics International to help meet the world's power needs.

This is the ORGANIC POWER REACTOR—outgrowth of research and development on the organic system and operation of the Organic Moderated Reactor Experiment (OMRE) conducted by Atomics International for the U.S. Atomic Energy Commission.

Outstanding advantages of the ORGANIC POWER REACTOR: Low capital investment • Low cost operation • High inherent safety and flexibility • Reliability

resulting from

- **Non-corrosive moderator coolant • Low pressure system**
- **Conventional, off-the-shelf components and materials**
- **Easy access during operation**

Atomics International is ready to furnish complete ORGANIC REACTOR electric power plants, including fuel elements, in a wide range of power levels. An experienced field staff will assist with initial plant operation, personnel training and maintenance procedures.

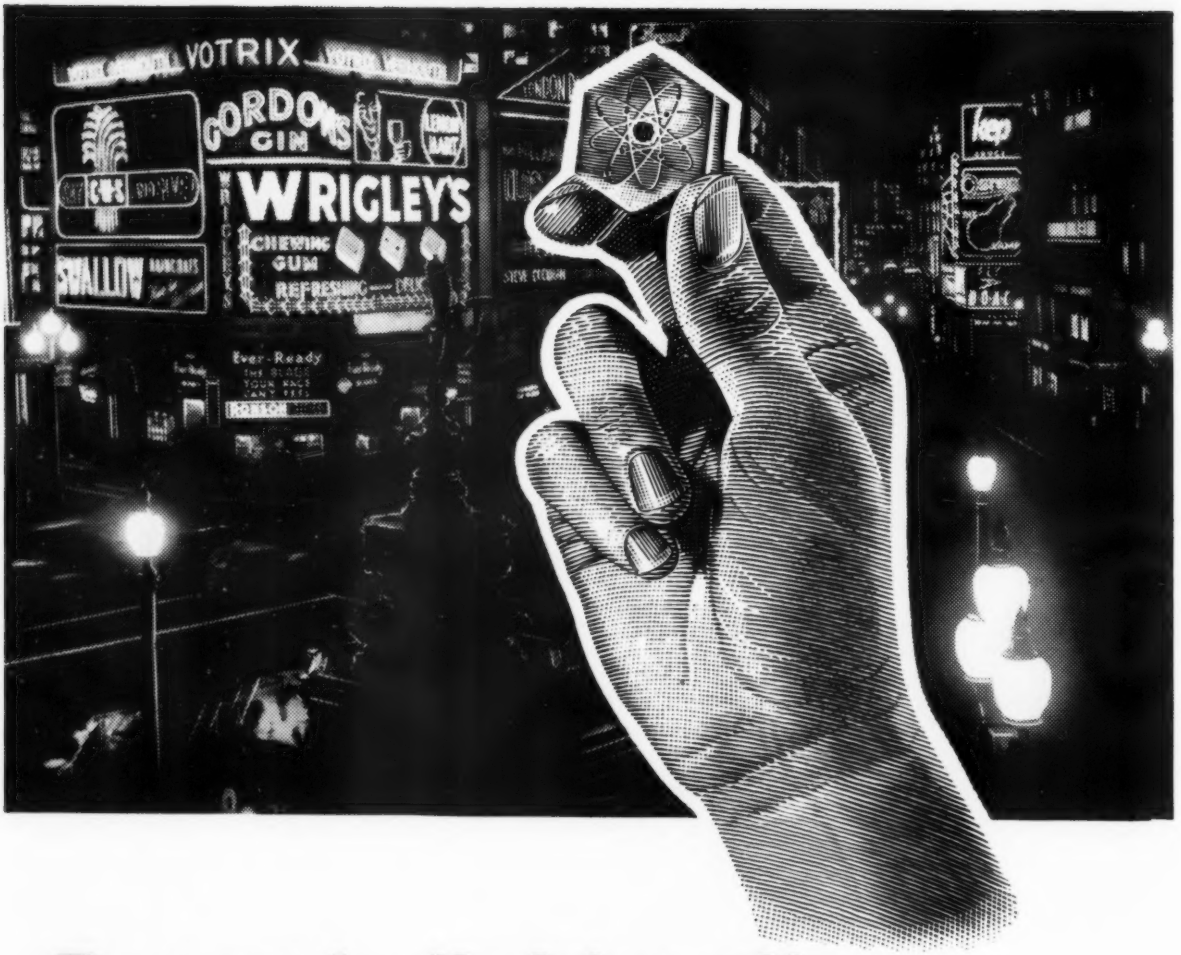
For details contact: ATOMICS INTERNATIONAL, Canoga Park, California, U.S.A. Cable address: ATOMICS.

ATOMICS INTERNATIONAL

A DIVISION OF NORTH AMERICAN AVIATION, INC.

PIONEERS IN THE CREATIVE USE OF THE ATOM

Other offices in: Washington, D.C., U.S.A.; Geneva, Switzerland, Affiliated with: INTERATOM, Bensberg/Cologne, Federal Republic of Germany



Power to light a city . . .

. . . when "Acheson" slows the neutron

Out of the atom comes power—power for peace—power for industry—power to light our great cities.

The tremendous speed of fission particles must be greatly reduced so that man can harness their energy. To achieve this in the Calder Hall Reactors specially pure "Acheson" graphite is used as a moderator.

In close collaboration with the United Kingdom Atomic Energy Authority, 5,000 tons of "Acheson" graphite conforming to an exceptionally strict specification for purity were supplied from current output for the Calder Hall 'A' Reactor. This project demanded considerable production capacity backed by the highest technical skills and experience gained from many years producing "Acheson" graphite for the British Chemical, Electronic and Mellallurgical Industries.

Now at the threshold of a New Age of Atomic Power, British Acheson are already ahead with immense expansion programmes to provide "Acheson" graphite for the new demands of Atomic Energy. Last year alone the capacity at Sheffield works was increased by 200 per cent.

British Acheson Electrodes Limited is continuing to anticipate the changing trends and new demands of British Industry.

ACHESON TRADE MARK **GRAPHITE**

The term ACHESON is a registered trade mark

BRITISH ACHESON ELECTRODES LIMITED · WINCOBANK SHEFFIELD · PHONE: ROTHERHAM 4836

SEE US AT
STAND 13
Outer Row Gallery
National Hall
ENGINEERING EXHIBITION
April 16th to 30th
OLYMPIA

Expansion, contraction and lateral movement of pipe work under extreme conditions of temperature and pressure is no problem to the engineer who has been wise enough to contact and consult TEDDINGTON technicians.

Teddington Bellows Expansion Joint cylinders are butt-welded from highly finished cold rolled stainless steel sheet. Convolutions are introduced to give the bellows their characteristic flexibility. Nuclear, chemical, marine and gas engineers acknowledge their efficiency and superiority over many older forms of expansion joint. Wherever pipework is subjected to vibration or movement in any direction, a Teddington Bellows with a suitable end-fitting will solve the problem.

SEND FOR BROCHURE No. R 47

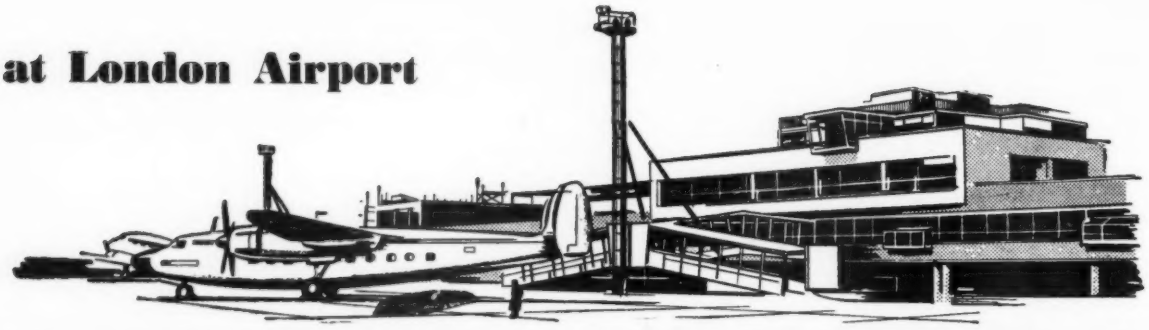
Teddington Bellows are produced in technical collaboration with the Solar Aircraft Co., U.S.A.

TEDDINGTON BELLOWS
EXPANSION JOINTS

TEDDINGTON AIRCRAFT CONTROLS LIMITED, INDUSTRIAL BELLOWS DIVISION
Ammanford, Carmarthenshire. Tel: Ammanford 2255

Tick **No 61** on reply card for further details

at London Airport



CORRUSTEEL

ARMOURED
CABLE

wandleside
of
wandsworth

Illustration shows "CORRUSTEEL" Armoured Cable in the Main Feeder Trunking at London Airport's new building. Electrical Contractors, The L.E.B. Contracting Section, Chelsea Manor Street, S.W.3

WANDLE BRITISH MADE CABLE

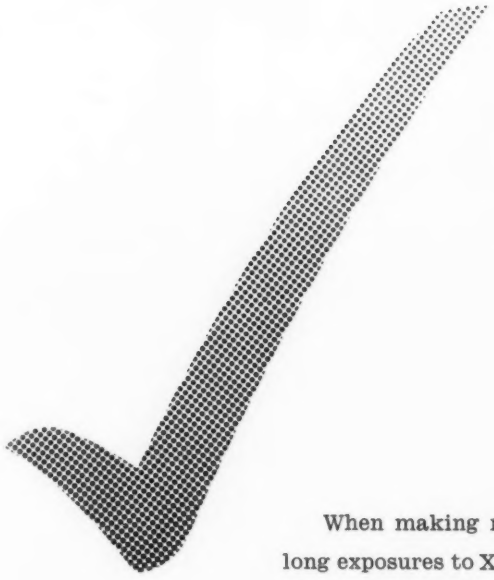
WANDLESIDE CABLE WORKS LTD. **106 GARRATT LANE · WANDSWORTH · LONDON S.W.18**

Telephone: VANdyke 7544 (7 lines)

Telegrams: "Wandleside, London"

One of **FALKS** Group.

OFFICES. LONDON : 21 Fitzroy St., London, W.1. BELFAST : 1 Advance Factory, Derriaghy, Dunmurry. BRADFORD : 19 Union St., Bradford, Yorks



RIGHT
– first time

When making radiographs by gamma-rays, or by long exposures to X-rays, make your trial exposures on the very fast 'Kodirex' film.

Then refer to the 'Kodak' *Density Conversion Guide*. This will tell you the correct exposure for the film you normally use.

This method can save you hours every day. You won't have to wait so long for the results of your test exposure, and you get your working exposure right first time.

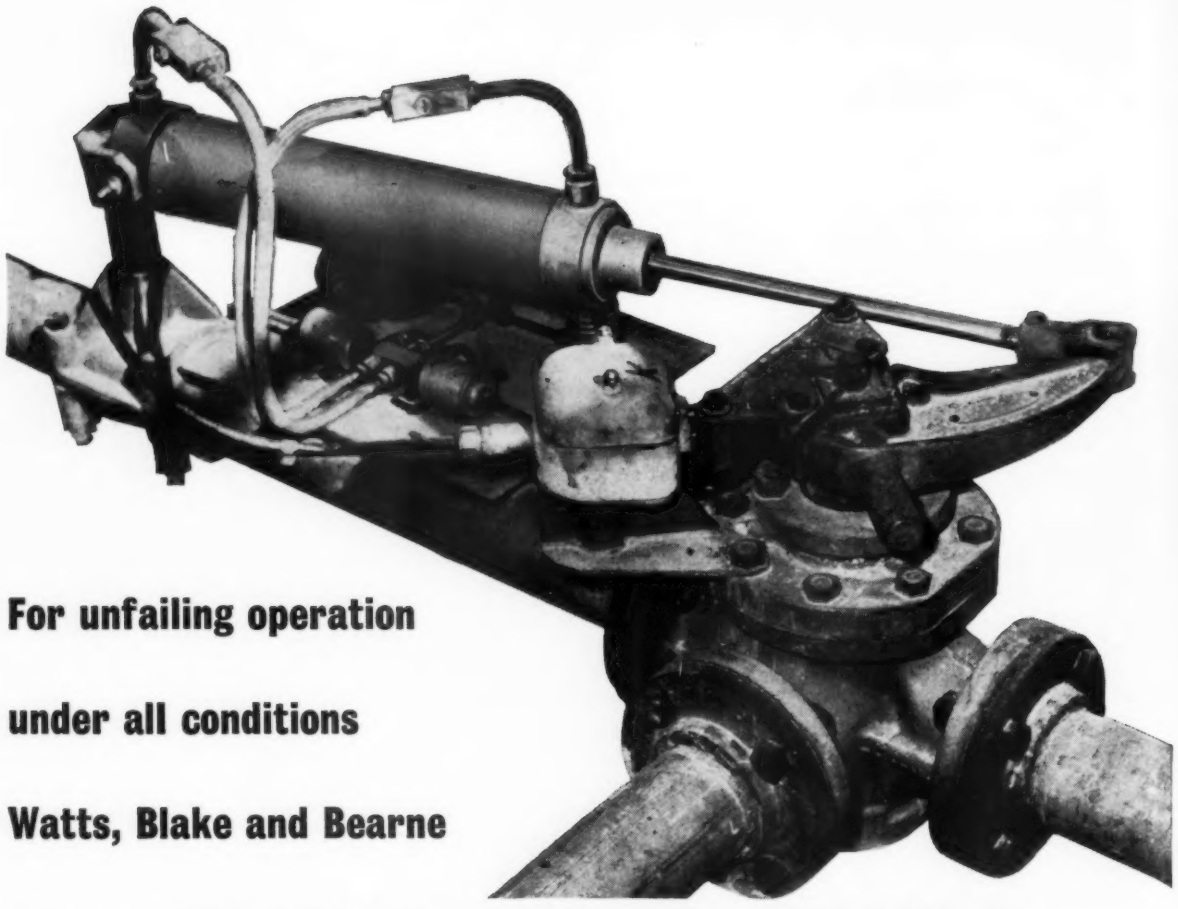
As part of the Kodak service to industrial radiologists, the *Guide* is offered to you free.

Kodak

services to industrial radiologists

Kodak will also calibrate your X-ray set and provide charts showing the correct exposure for different metals and for various film speeds. This, too, is a free service.

Kodak Limited, Industrial Sales Division, Kodak House, Kingsway, London, W.C.2



For unfailing operation

under all conditions

Watts, Blake and Bearne

rely on MAXAM FLUID POWER

Correct sequence and dependable full-bore opening are essential for the remote control of valves controlling the flow of china clay slurry from settling tanks via pressure vessels to filter presses. At the Cornwood quarry of Messrs. Watts, Blake and Bearne, the pipeline valves over an area of several acres are operated pneumatically from a single control panel adjacent the filter presses. The six-inch diameter slurry pipelines, Tee-port valves, MAXAM control valves and MAXAM pneumatic cylinders are exposed on high moorland country, but the control system never fails—even when adverse weather conditions may affect the operation of the equipment. MAXAM pneumatic/hydraulic equipment has proved completely reliable in every undertaking—mines, quarries, sand and shingle excavation sites, cement handling, or road-stone grading and coating plant—where dust and exposure would normally cause rapid wear and unreliable operation of controls manufactured to traditional patterns.

In fast, automatic machines designed for the repeated operation of several interlinked sequences necessary in flow production, MAXAM valves, cylinders and associated products have similarly demonstrated prompt, precise and unfailing response: **66% of current production is for companies whose designers—with experience of MAXAM performance and reliability—have planned their future flow production machines with MAXAM Fluid Power in mind!**

If you are a Chief Draughtsman, Works Manager, Production Head, or other person seriously interested in safely increasing productivity, please send for our catalogue.

MAXAM POWER LIMITED

Camborne, England. Camborne 2275 (10 lines)
London Office:
44 Brook Street, W.1. HYDe Park 9444

THE HOLMAN GROUP

A company in the Holman Group which has branches, technical representatives and agents throughout the United Kingdom and the world

MAXAM *Fluid Power Equipment*

MA3

Tick **No 64** on reply card for further details

See us at Stand No. 4U, (Empire Hall), The Engineering, Marine, Welding & Nuclear Energy Exhibition, Olympia, London, from 16th—30th April, 1959.

Complete Welding Installations by

LINCOLN

A typical installation for pressure vessel and similar work incorporating a LINCOLNWELD B.10 Fully Automatic Submerged Arc Welding Head, the LINCOLN L.R.C. Revolving Column and Travelling Boom and LINCOLN L.S.A.R. Self-Aligning Variable Speed Rotators.

★ **AUTOMATIC AND SEMI-AUTOMATIC SUBMERGED ARC WELDING UNITS**

★ **POSITIONING AND MANIPULATIVE EQUIPMENT**

★ **WIRES AND FLUXES FOR MILD STEEL, ALLOY STEELS AND HARDFACING**

★ **AFTER-SALES SERVICE**

Sooner or later YOU will become interested in Submerged Arc Welding.

LINCOLN have a COMPLETE range of Submerged Arc Welding Equipment PLUS

★ Hundreds of successful installations.
★ Years of knowledge acquired throughout the world.
★ A fully trained staff of Design and Welding Engineers.

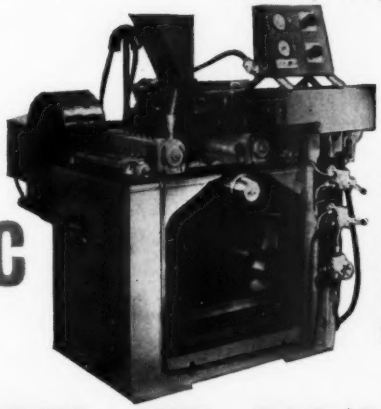
Let LINCOLN be YOUR Welding Consultant.

Please write to:

The Automatic Division

LINCOLN ELECTRIC COMPANY LIMITED

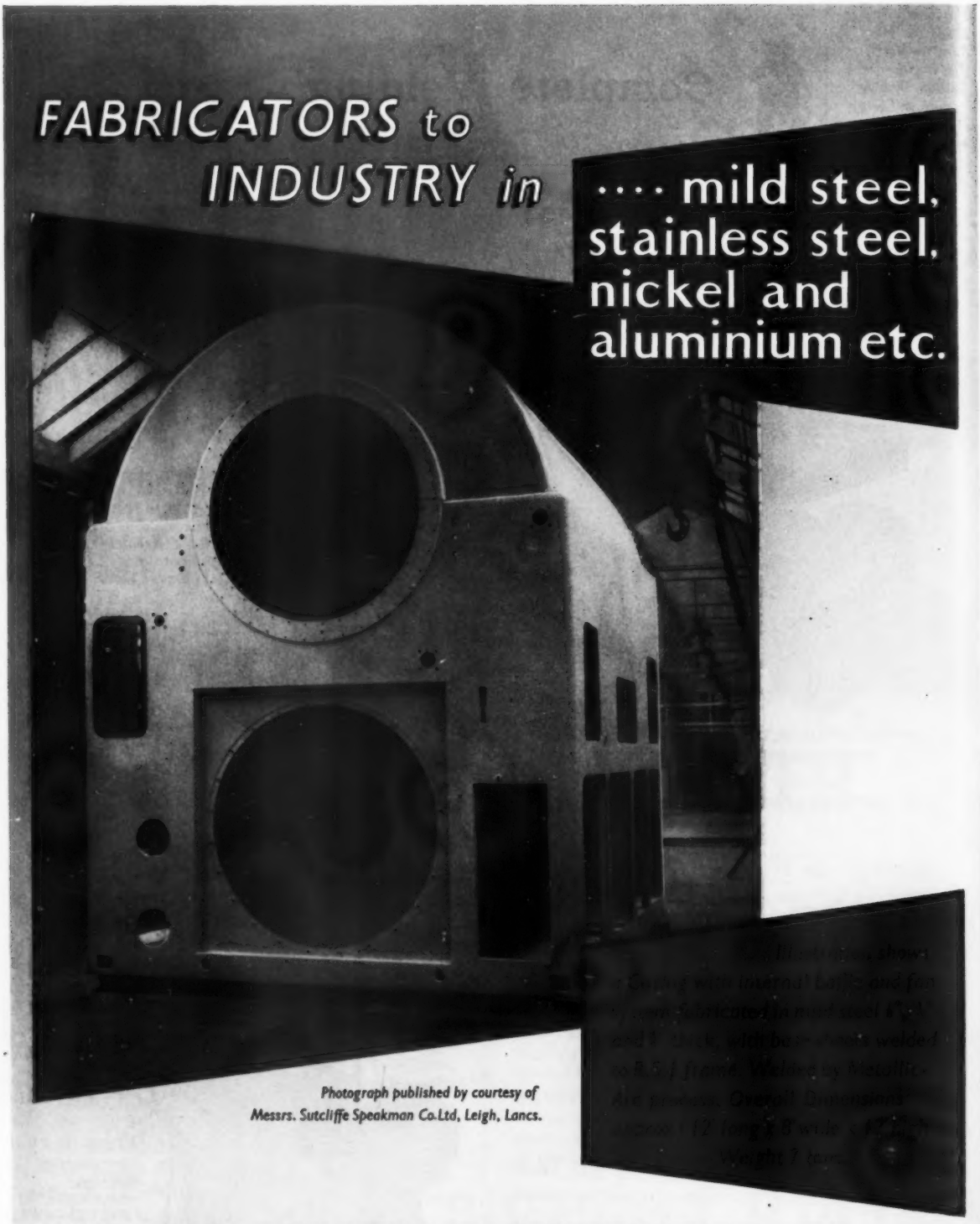
The LINCOLN 150 L.V.P. Variable Speed Positioner (load capacity 7½ tons)



A LINCOLN Seam Welding Machine, incorporating the LINCOLNWELD M.L.3. Remote Control Automatic Submerged Arc Welding Unit.

WELWYN GARDEN CITY · HERTS · TEL: 920/4 4581/5

P6E

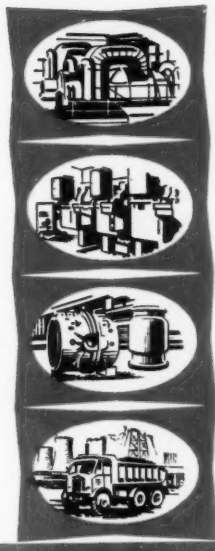


UNIVERSAL BOILERS & ENGINEERING CO. LTD

HEAD OFFICE: FULLEDGE WORKS - BURNLEY - LANCASHIRE - ENGLAND
Telephone: 3121/2 and 3203 Burnley (3 Lines) Telegrams: 'UNIVERSAL' Burnley

Associated with BURNLEY AIRCRAFT PRODUCTS LTD. Fulledge Works Burnley Telephone: 3121/2
GROSVENOR STREET, STONEYHOLME, BURNLEY Telephone: 3184
and BRITANNIA WORKS, QUEENSGATE, BURNLEY Telephone: 4102

These names make NUCLEAR POWER

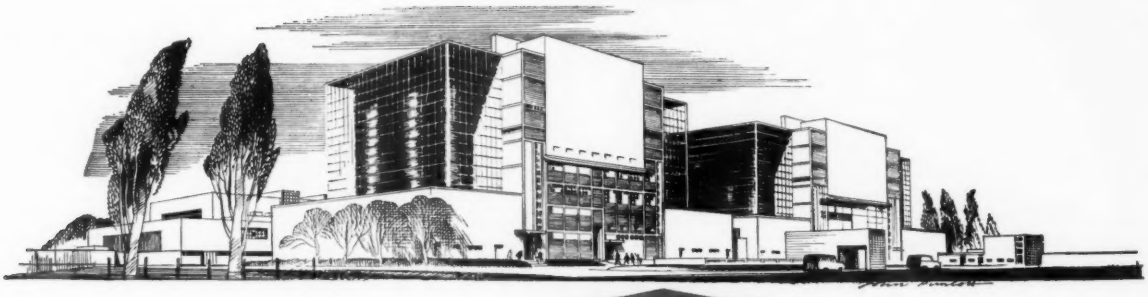


C. A. PARSONS & CO. LTD.

A. REYROLLE & CO. LTD.

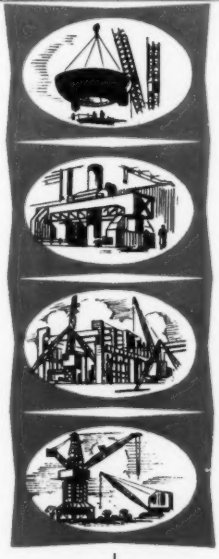
HEAD, WRIGHTSON & CO. LTD.

SIR ROBERT McALPINE & SONS LTD.



Bradwell, Essex, has leapt into fame as the site of the first commercial nuclear power station in the world to be built by N.P.P.C. Eight names make The Nuclear Power Plant Company Limited. N.P.P.C. thus combines the resources of eight specialist companies whose individual skills are co-ordinated to form a unified team capable of undertaking the construction of complete nuclear power stations throughout the world.

Bradwell nuclear power station will have a guaranteed output of 300 Megawatts. It is being built by The Nuclear Power Plant Co. Ltd. for the Central Electricity Authority.



WHESSOE LTD.

STRACHAN & HENSHAW LTD.

ALEX. FINDLAY & CO. LTD.

CLARKE, CHAPMAN & CO. LTD.

A Greater Britain through NPPC Nuclear Power

THE NUCLEAR POWER PLANT COMPANY LIMITED · BOOTHS HALL · KNUTSFORD CHESHIRE

TGA NP3

THE RIO TINTO GROUP

is now able to supply uranium in commercial quantities for power and research programmes. The nuclear grade products now available include the following:

Ammonium Diuranate	Uranyl Nitrate Hexahydrate
Standard Grade Uranium Dioxide	Ceramic Grade Uranium Dioxide
Uranium Tetrafluoride	Uranium Metal

Uranium metal is normally supplied as machined ingot but facilities exist for forging and rolling to special sizes and shapes to meet individual requirements.

Prices and specifications on application to
Rio Tinto Management Services (UK) Limited
Barrington House, Love Lane, London, E.C.2
TELEPHONE: METROPOLITAN 9101

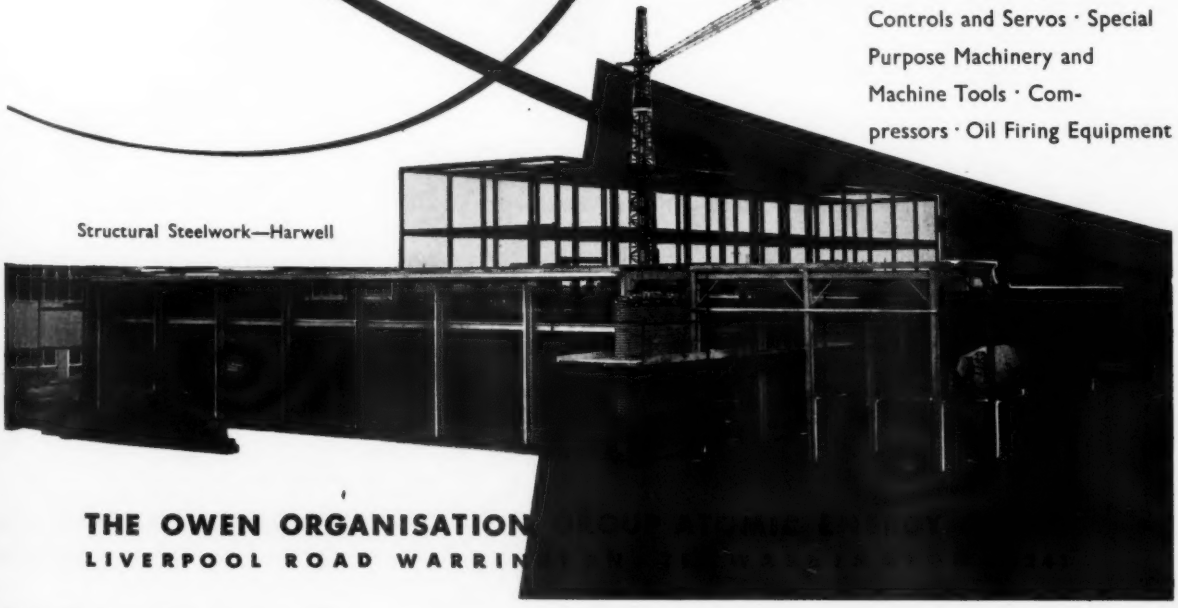
Co-ordinated Resources for Service in the Nuclear Field

Solenoid operated valve orifice 0.25 millimetres

The Owen Organisation

The resources of the Owen Organisation are co-ordinated to serve the Nuclear Industry in Design, Development and Manufacture

Argonarc Welding · Rowenarc Welding · Hydraulic and Pneumatic Actuating Systems and Valves · Design and Research Facilities · Prototype manufacture facilities · Production Facilities · Patented Copper free brazing for steel, stainless steel, Niobium, etc. · Fork Trucks and Materials Handling Equipment · Pressure Vessels · Test facilities, including Hydraulic, Pneumatic, Mechanical · Test facilities for Prototypes · Structural Steel work · Metal Equipment, Partitioning, Bins and Furniture · Remote Control Equipment · Cold and Hot Presswork · Fabrication work · High Tensile Bolts · Package Irradiation Plants · Electro-Hydraulic Controls and Servos · Special Purpose Machinery and Machine Tools · Compressors · Oil Firing Equipment



Structural Steelwork—Harwell

THE OWEN ORGANISATION

LIVERPOOL ROAD WARRIN

Tick No 69 on reply card for further details

Winfrith Exponential Stack under construction at the Graviner Works

There will be a model showing the graphite components of the Reflector of the Chalk River ZED 2 Reactor under construction for the Foster Wheeler Co of Ontario

ENGINEERING, MARINE WELDING & NUCLEAR ENERGY EXHIBITION
APRIL 16–30

Visit Stand 3M National Hall Olympia and see the complex graphite components machined for NUCLEAR ENERGY Projects

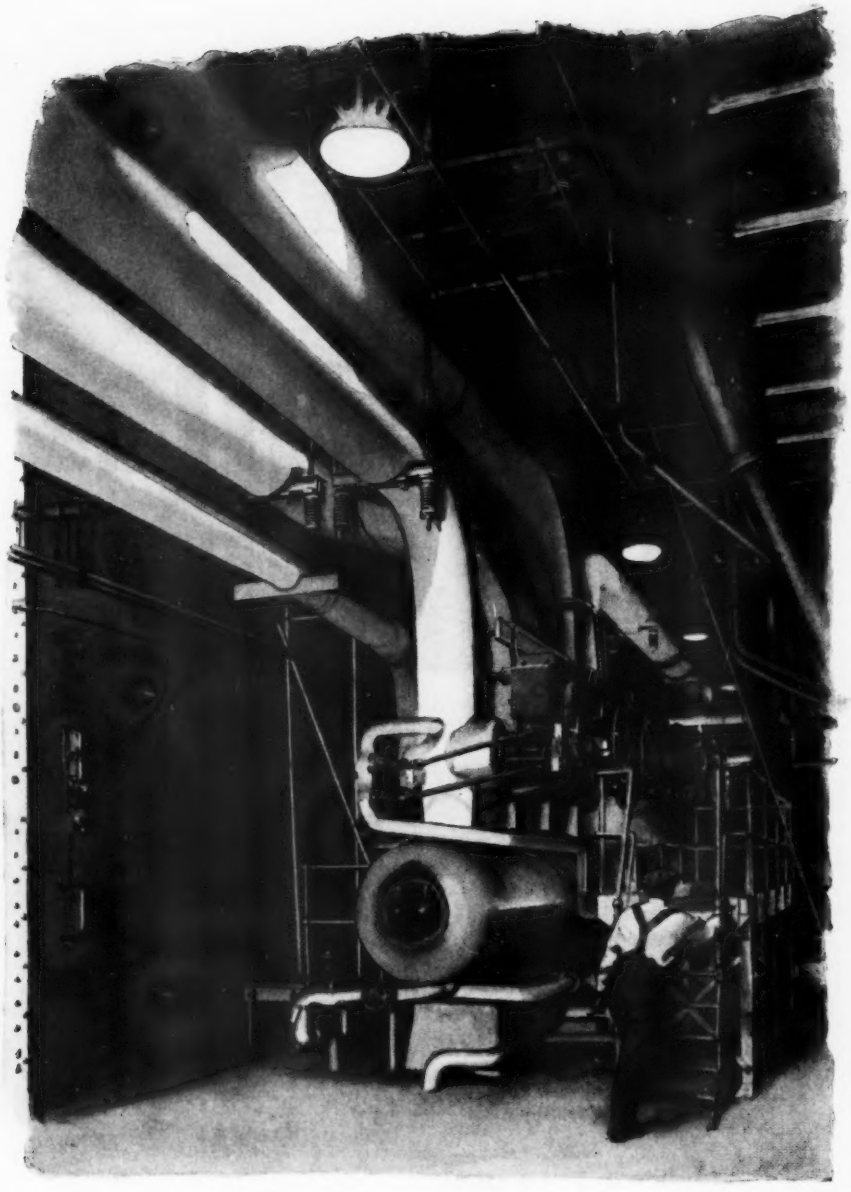
GRAVINER

MANUFACTURING COMPANY, LIMITED
FAREHAM ROAD, GOSPORT, HANTS. Telephone: FAREHAM 2511

Specialists in Airborne, Diesel Engine and Industrial Fire and Explosion Protection, Thermostats and Overheat Switches

S&L

Tick No 71 on reply card for further details



POWER PLANT PIPEWORK

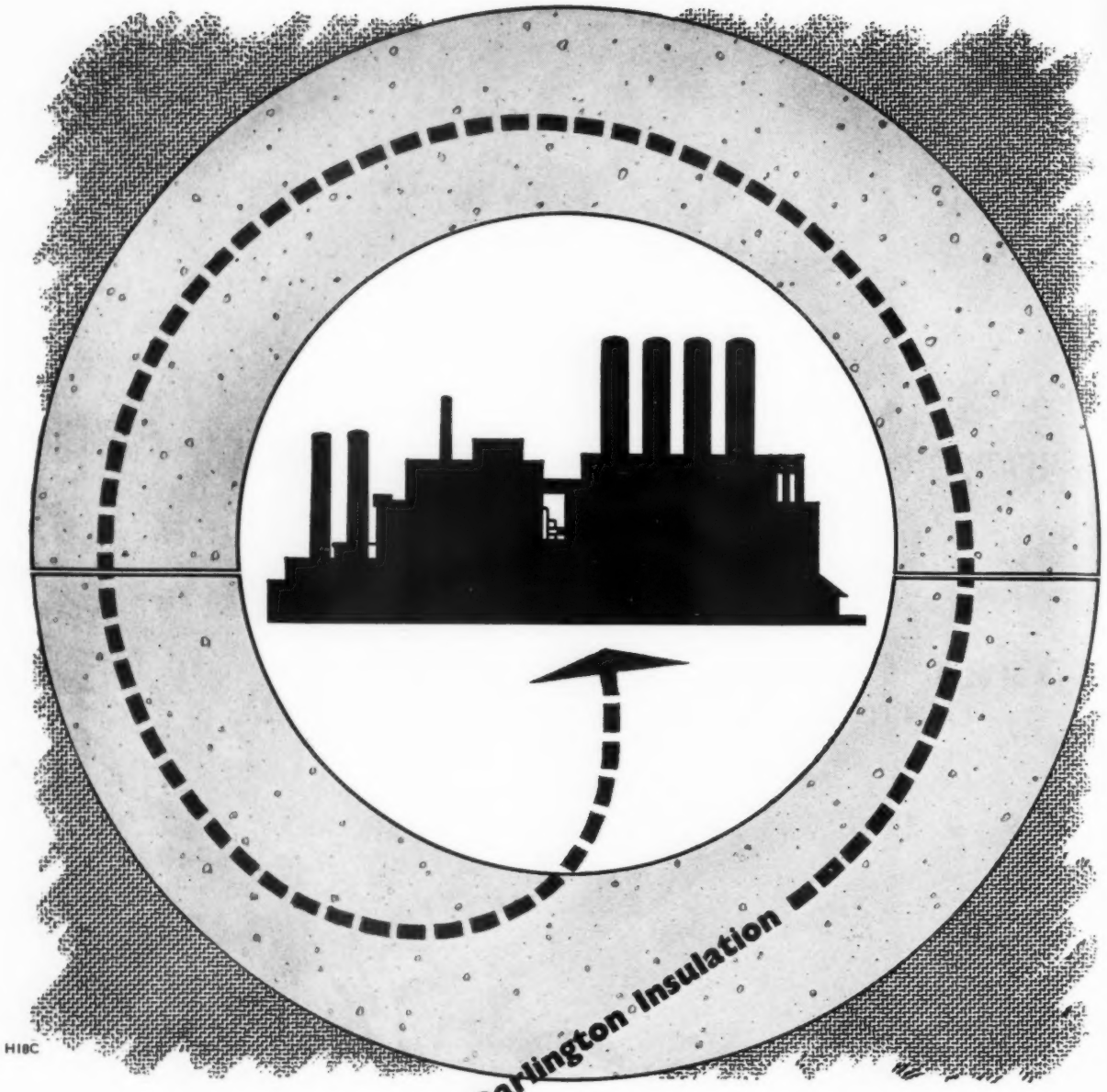
We design, manufacture, manipulate and install pipework for all types of industrial plants and are able to provide a comprehensive service to our customers.

In addition to pipework for general services, our range of products includes steam, gas, water and air mains, coils, tubes for boilers and heat exchangers. We also supply tubes and rectangular hollow sections for mechanical and structural purposes.

STEWARTS AND LLOYDS LIMITED

GLASGOW · BIRMINGHAM · LONDON

We invite you to visit us at the Engineering, Marine Welding and Nuclear Energy Exhibition, Olympia, April 16-30, Stand No. 4, Row E, Ground Floor, Grand Hall.



Year after year the Central Electricity Generating Board's list of power stations with the highest operating efficiencies includes a majority of stations where the efficiency is guarded by Darlington Insulation. In the 1957 list, for example, the top four stations are Darlington insulated.
Coincidence ? Not a bit of it ! Just skill and years of experience, plus careful specifications and the right materials.
It's The Darlington Insulation Company's job to help maintain high thermal efficiencies, and they do it very well.

THE DARLINGTON INSULATION CO. LTD

38 Great North Road, Newcastle upon Tyne, 2
and branch offices at London, Birmingham, Bolton, Bristol, Cardiff, Glasgow, Leicester and Sheffield.

A Member of The Darlington Group of Companies

HEAT & SOUND INSULATION EXHIBITION
EARLS COURT
APRIL 7—17, 1959
SEE OUR EXHIBIT

Tick No 73 on reply card for further details

WESTON

MOVING COIL

RELAYS

The simplicity and reliability of relay control for a wide variety of applications has led to the ever increasing use of Weston Moving Coil Relays. Let us have a note of your relay problems and we will be pleased to advise on the most suitable model for any set of conditions. Enquiries should, if possible, be accompanied by full particulars of both control and local circuits.

Illustrated is the Model S170. Other types include the Model S124, a magnetic contact relay which operates with a minimum power input of 0.004 microwatt and the Model S115, a miniature relay, which functions as an "on-off" switching relay.

SANGAMO WESTON LIMITED
ENFIELD · MIDDLESEX
Tel: ENField 3434 (6 lines) & 1242 (6 lines) Grams: Sanwest, Enfield

Scottish Factory: Port Glasgow, Renfrewshire, Port Glasgow 41151
Branches: London, CHAncery 4971 · Glasgow, Central 6208 · Manchester, Central 7904
Newcastle-upon-Tyne, Newcastle 26867 · Leeds, Leeds 30867 · Liverpool, Central 0230
Wolverhampton, Wolverhampton 21912 · Nottingham, Nottingham 42403 · Bristol, Bristol 21781 · Southampton, Southampton 23328.

SW/67

Publishers Column

Jason and us

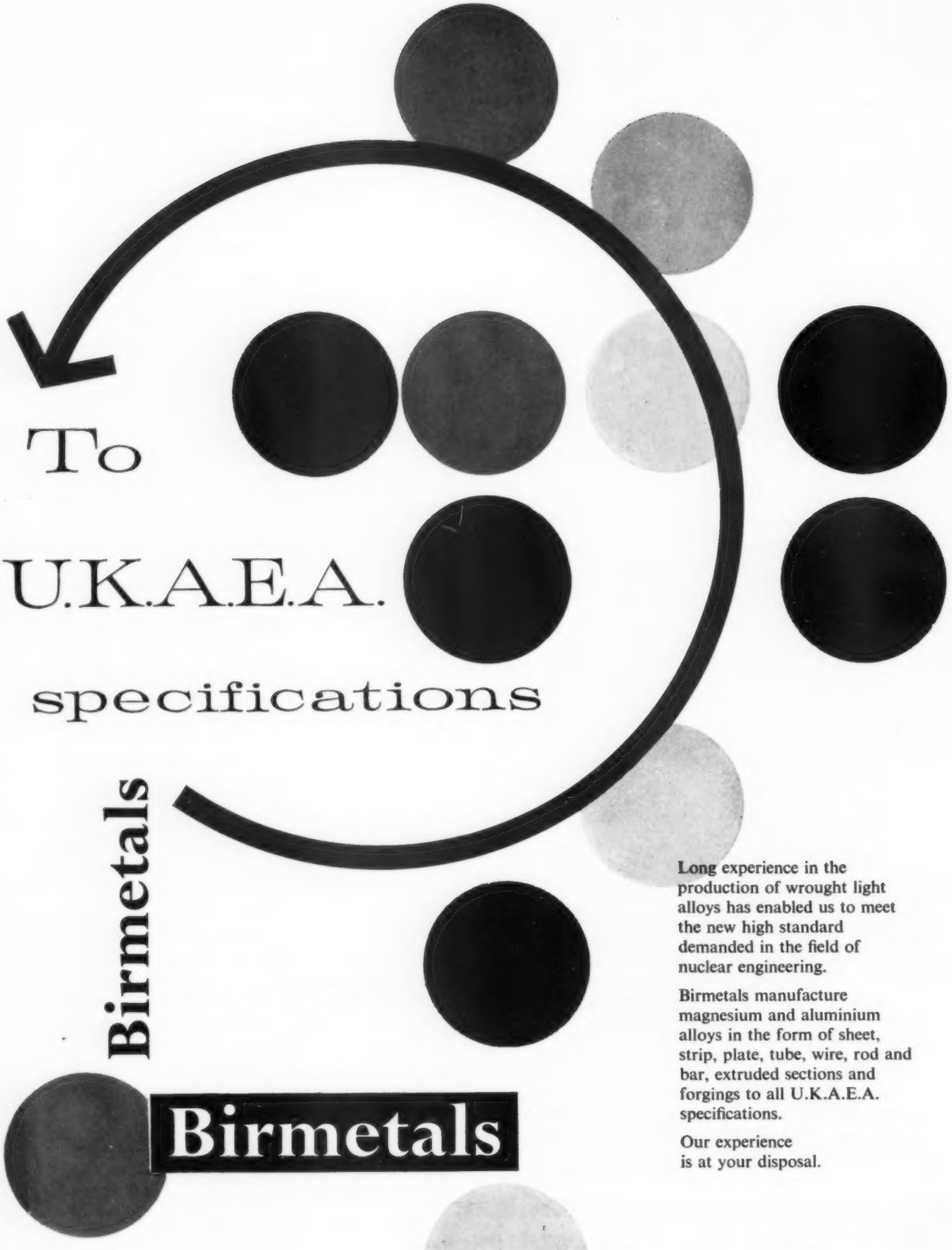
Dates can be the most infuriating things. Last month we featured a ten-page review entitled 'What's available in Laboratory Reactors' and one of these reactors happened to be the Jason—the only one at present manufactured by a British firm. Now while we were working on the article we were told by Hawker Siddeley that they were going to build a prototype at their Slough works but that they particularly wanted no announcement made until Friday, February 27. As NUCLEAR POWER was due on the bookstalls on February 26 this was annoying since the topical story would have tied in neatly with the feature. However we could not betray the confidence we'd been given and so it had to be held—just for the sake of one day.

This however was not the end of the Jason story. When Hawker Siddeley saw the magnificient drawing that Theo Page did for us they were most anxious to include copies of this with their literature on the reactor, for it showed at a glance all the details. It meant of course that this particular page had to be reprinted apart from the journal. But the magazine did not finish printing until the early hours on Wednesday morning and Hawker Siddeley said they must have the reprints by mid-day.

As soon as the final sheets were printed the block of the drawing was taken out of the forme and transferred to a smaller machine and the required number run off. The reprints were collected early on Wednesday afternoon and before the day was out they and the firm's literature were on their way to news media all over the world for release on Friday morning.

Soon every university in the world with an engineering or physics department will receive copies of this drawing incorporated in a reprint of that portion of our article dealing with Jason.

Now we hear the firm have sold one of these reactors and Britain may be said to be in business in this small but important field.



Birmetals

Long experience in the production of wrought light alloys has enabled us to meet the new high standard demanded in the field of nuclear engineering.

Birmetals manufacture magnesium and aluminium alloys in the form of sheet, strip, plate, tube, wire, rod and bar, extruded sections and forgings to all U.K.A.E.A. specifications.

Our experience is at your disposal.

BIRMETALS LIMITED · WOODGATE WORKS · BIRMINGHAM 32

BM 237

74 Tick **No 74** on reply card for further details

Tick **No 75** on reply card for further details

THE SIGN OF QUALITY

Available as straight and right-angle entries, bulkhead fittings etc. for operation from 5 to 30 kv. Fully approved. Please write for our Comprehensive Booklet E.H.T.1.

M. B. METALS LIMITED
VALE WORKS
PORTSLADE, SUSSEX
TELEPHONE: HOVE 48623

SIR! LETTERS TO NUCLEAR POWER

The Editor welcomes correspondence for publication

Isotopes and factory regulations

SIR: I was particularly interested in your article last month *Isotopes and the Factory Regulations* and I quite agree with the author's implied comment that this whole issue should have been settled years ago. Libby's widely-quoted figures of savings to US industry by the adoption of isotope techniques have of course been greeted with waves of disbelief in Britain but there must be some considerable substance in them and there is little doubt that a similar survey conducted here would reveal a comparable situation. Unless and until, however, an acceptable set of regulations becomes law we can expect little enthusiasm in industry for nucleonic equipment which may easily involve the user in considerable personnel problems. I understand a Bill is expected later this year. Let us hope it will pave the way to great things.

Manchester, 17 K. V. F. STANHOPE

▶ *The UK Atomic Energy Authority have undertaken a Libby-type survey in Britain and we understand their report should be available soon. In the House of Commons recently the Parliamentary Secretary to the Ministry of Labour said it was hoped to publish draft regulations this year. They would cover two classes of source—sealed and open.* *Ed.*

The deep end

SIR: With reference to your article 'What's available in Laboratory Reactors' last month, could I ask what is the difference between a pool reactor and a tank reactor?

Leamington, Warwicks W. P. MATCHAM

▶ *We too have had some difficulty in arriving at a clear definition of the difference between these two, and it seems that the authors of the textbooks have come across the same problem. Apparently the first pool was a mock-up for the Materials Testing Reactor and was built in* 1950. *This actually looked like a swimming pool and the core was suspended from a movable bridge. Water acted as moderator, reflector and shield, and cooling was by natural convection. In the first tank type—the actual* MTR *at the NRTS, Idaho—the water was contained in a cylindrical tank. By itself, it was inadequate for shielding and external reflector and shields were incorporated; cooling was by forced convection.*

Although pools and tanks have become increasingly similar, the one basic difference seems still to be that in a pool the water is static and is essentially part of the reactor, while in a tank it circulates for cooling and its level is not fixed by shielding requirements. *Ed.*

Fuel for research

SIR: In your otherwise admirable review on laboratory reactors for research and training you say little about fuel and in many cases this could well be an overriding consideration. In the case of a British-built JASON reactor for example where would it come from and how much would it cost?

Neuilly-sur-Seine
France J. LACOSTE

▶ *The United Kingdom AEA have always said that*

'SOCAST' STEEL CASTINGS

BY PRECISION METHODS

An increasing number of manufacturers of plant are using components cast by precision methods. In many instances, components previously machined from the solid are being produced as castings with marked economies.

Intricate designs may be cast in stainless and many other steels to close tolerances, with good surface finish and freedom from porosity. Machining allowances are drastically reduced, and often eliminated.

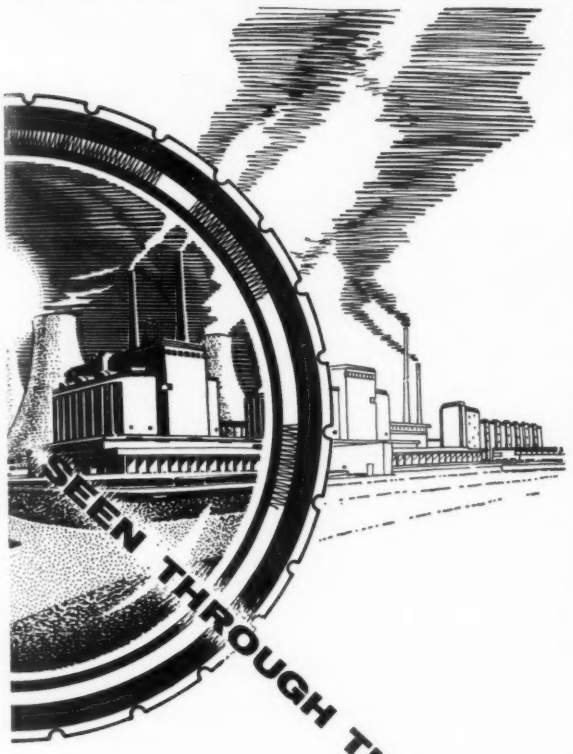
Reduce *your* manufacturing costs and expedite production by high quality *'SOCAST'* steel castings, which will withstand high pressures and avoid many repairs and rectifications in the machine shop.

OSBORN

FINE STEEL MAKERS · STEEL FOUNDERS
ENGINEERS' TOOL MAKERS

SAMUEL OSBORN & CO., LIMITED
CLYDE STEEL WORKS SHEFFIELD

Tick **No 77** on reply card for further details



Seen through the lens
of camera and projector,
many hidden facets of industry
come into focus — when Turners'
operators put them in the picture.
Public relations, staff recruitment and
training, publicity, selling and
many other problems respond to their
knowledge and experience of
film production in industry.

TURNERS FILM PRODUCTIONS
have already brought profit to industrialists
throughout the country. You are invited
to write, 'phone or
call for details.

TURNERS

FILM PRODUCTIONS

Camera House, Pink Lane, Newcastle upon Tyne, 1.
Telephone : Newcastle 2-5391

SIR!

continued from p 75

enriched fuel would be 'made available' for British reactors built at home or overseas, provided of course that a bilateral agreement existed between the two parties. On what basis this is to be done has never been publicly made clear and no firm costs have ever been revealed. It is likely that in the case of JASON, *which uses enriched fuel, the material would be rented.*
Ed.

Boiling nomenclature

SIR: In a recent article H. A. Roberts and R. W. Bowring (NUCLEAR POWER *Jan* 58 p 122) made a plea for precise definition in the terminology applied to boiling phenomena. Their appeal is the more telling after consideration of the amount of literature they must have reviewed in the past five or ten years. Whilst no justification is required for duplication of experiment on most aspects of boiling heat transfer, the stage has been reached, I think, where additional heat transfer correlations must carry *adequate* proof of their usefulness.

Consider, for example, *forced convection subcooled boiling* of water. Is it possible to agree to any particular set or sets of experimental results being representative of conditions in this region of boiling heat transfer? Could this be done, we should all be saved much uncertainty if future investigators in this region were to apply their formulation to this set of results as well as to any others of their choice. This applies particularly to boiling correlations originating in the United States where there are at least two distinct centres of boiling heat transfer research, separated as much by geographical consideration as any other.

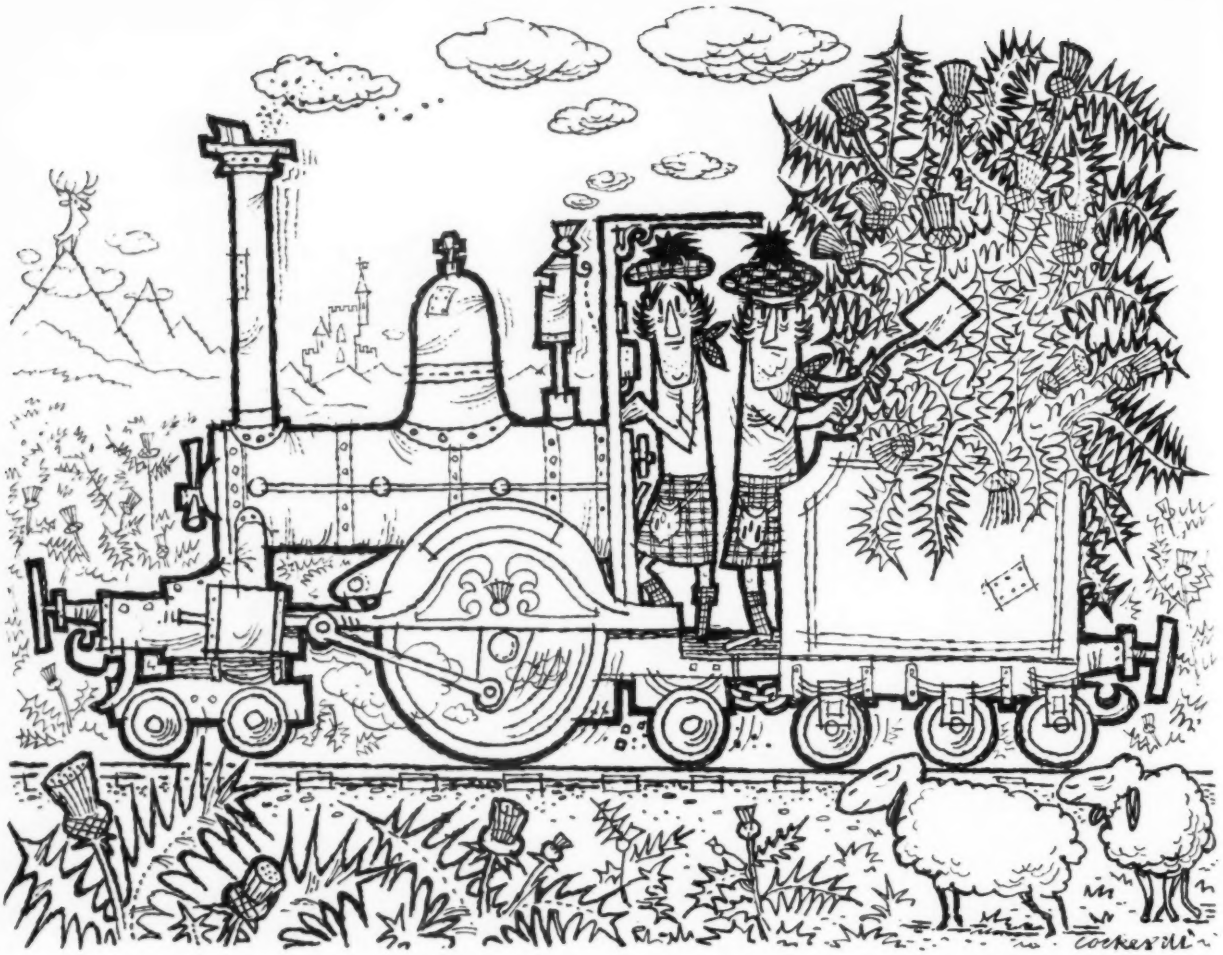
Most publications on boiling heat transfer include the graph, plotted using logarithmic scales, of heat flux against temperature difference (see Roberts and Bowring *loc. cit.*). This diagram explains most clearly the differences in the phases of the boiling process. When, however, the characteristics of any individual phase is represented, it seems to me highly probable that this form of presentation of results can be misleading and that a linear plot of these results should always be made. This applies particularly at the approach to a transition region, e.g. between the non-boiling and surface nucleate boiling region or near the critical heat flux.

Because of the variation of temperature difference over which the *critical heat flux* exists, I am less willing to accept the term *critical temperature difference* than are Roberts and Bowring.

If our interest lies mainly in the nucleate boiling region, we must not forget the assistance which may be available from those interested in other nucleation problems, such as cavitation, condensation etc—such association would not be one-sided and it is easy to make a good case for much more active cooperation.

These points are of very limited interest but, if the atomic energy industry is to be responsible for an increase in attention to this specialized subject, then this seems a reasonable time and place to record them.

Edinburgh T. D. PATTEN



'SPIKED FUEL'

Every schoolboy knows that to spike a man's guns renders him (and the artillery) powerless. Tomorrow's schoolboys may be more familiar with a different spiking technique—and one which has the opposite effect, that of stimulating activity.

The efficient functioning of a nuclear reactor depends on the fuel "burning" — discharging neutrons — at the correct rate. If necessary, the neutron discharge can be stepped up by "spiking" the reactor with a special type of fuel element embodying a particularly active fuel, such as plutonium or highly enriched uranium.

The task of preparing and sheathing these special fuels is only one of many exacting demands which nuclear engineering has made upon the skill of the metallurgist.

Since producing Britain's first fabricated uranium fifteen years ago, I.C.I. Metals Division has made several notable contributions to nuclear metallurgy.

Today, the technical resources and practical experience of the Division are geared to meet the increasingly stringent demands of a major industry.

ICI METALS DIVISION

IMPERIAL CHEMICAL INDUSTRIES LIMITED, LONDON S.W.1

PRS

Nuclear Power
REACTORS · MATERIALS · INSTRUMENTATION · PROCESSES · IRRADIATION
APRIL 1959 VOLUME 4 NUMBER 36

More scope for industry

'To produce, use and dispose of atomic energy and carry out research into any matters connected therewith.' That is the first object of the United Kingdom Atomic Energy Authority as defined by the Atomic Energy Act 1954. And it's quite a lot. Now that sweeping changes are taking place in the top levels of the Authority this might be a good opportunity to examine how its duty has been discharged.

Much depends of course on what one means by 'atomic energy.' But taking it in its very broadest sense to include bombs then it certainly has been produced, used and disposed of. On peaceful uses if we take 'atomic energy' to mean gas-cooled graphite moderated reactors, then we can also say 'mission accomplished.' This is no mean achievement and the nation owes a great debt of gratitude to Sir John Cockcroft and Sir Christopher Hinton whose inspired leadership brought this about.

All this was, of course, evident about two years ago and since then the Authority seems rather to have lost its way. During this time there has been a steady exodus of staff —some of them from the most senior positions—to industry, to the CEGB, to the universities. This not only indicates greater opportunity outside but suggests strongly a sense of growing dissatisfaction and frustration within the Authority. Even outside the fence the feeling is spreading. What, for example, is happening to the controlled thermonuclear project—now uneasily poised somewhere between Harwell, Winfrith and some airfield near Oxford, with its leader in America? Why is the Dounreay Fast Reactor over a year behind schedule? When are we going to do something about a liquid-cooled or boiling reactor? Which side—Risley or Harwell—is winning the ship war? When do we get cheap caesium-137? The fact that these questions remain unanswered shows that all is not well. Can it be that there is now no one of the authority of Cockcroft or Hinton to decide among the many pressure groups and special lobbies? Probably not. Up to the date of Calder Hall there was one clear object in view—plutonium—and there was only one way of making it. Now the aim is cheap power but the ultimate way of doing this is not absolutely certain. So there is diffusion of effort, false starts, dead ends, loss of momentum.

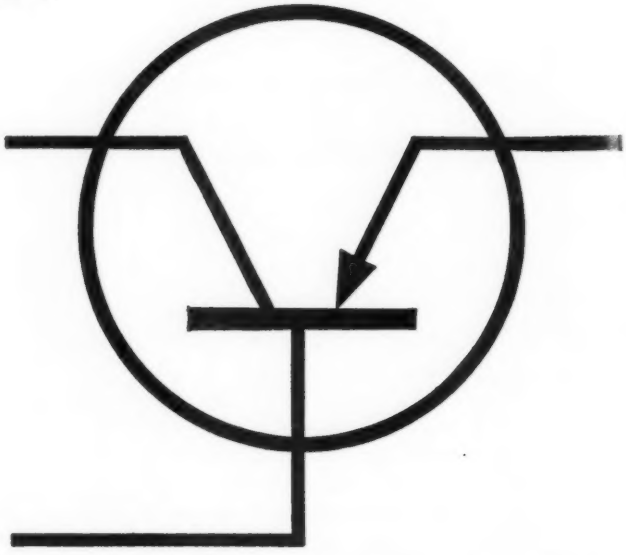
Is it not perhaps time that we had a good look at the basic organization of atomic energy in this country? We believe industry is able and willing to take a more active share in new projects and that quicker results could perhaps be obtained if more development contracts were placed.

There are dangers of course. Provision would have to be made so that the results of work done by one particular firm at Government expense is made available to other interested parties. Accounting would also have to be strict or we would have a repeat of the wildly spiralling costs that have plague the aircraft industry.

Nevertheless this can be done and the 1954 Act makes specific provision for it. Clause 2 (1) (e) allows the Authority 'to make arrangements with universities and other institutions or persons for the conduct of research into matters connected with atomic energy. . . . ' The clause also mentions grants or loans for this work. During the years this clause has of course been implemented to some degree but the time has come for a considerable expansion of the principle.

JUST THE TICKET

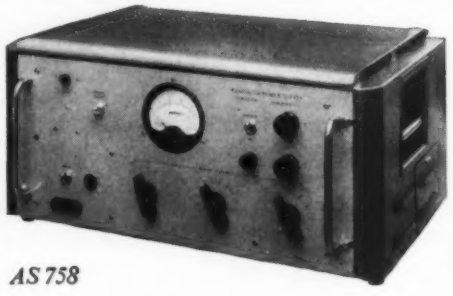
for any collector!



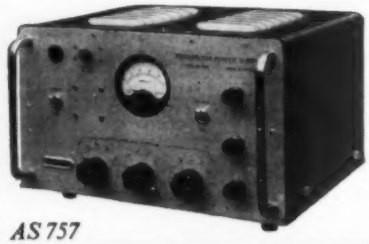
Transistors feel really secure fed from Solartron Transistor Power Supplies—precision rack, bench or sub-unit instruments built to the highest standards of craftsmanship in electronic engineering.

Real 'collector's pieces' in fact!

With assured fast response to load transients and providing highly stable output voltages inside ± 7% mains input change, this new Solartron range of Power Supplies offers the right unit for any transistor research task—or sub-units for direct incorporation into production equipment. Just the choice too to replace batteries—no worries of unobserved voltage decay or finding an exact supply level.



AS 758



AS 757

All bench units have 3-dial decade switching, with its inherently simple resetting facilities, also automatic overload cut-out and load current metering. The sub-units together cover the voltage range zero to 50 volts, with 3 V coarse adjustments and ±1.5 V fine control. Each sub-unit has a subsidiary 5 V (nominal) stabilised output, giving 0—10 mA.

Semiconductor devices are used throughout for control and rectification and all other components have been selected to ensure satisfactory operation up to 35° Centigrade, even at maximum load current and with mains input 7% above nominal. Due to careful design of control circuitry, capacitative loading may be used throughout the whole range of Solartron Transistor Power Supplies, without danger of instability.

Summarised specifications

	AS 757	AS 758	AS 759	AS 852	AS 854	AS 855
	Bench	Bench or rack	Sub-Unit	Bench or rack	Sub-Unit	Sub-Unit
Output voltage :	± 0 - 50	± 0 - 30	± 1·5 - 13·5	± 30 - 50	± 11·5 - 32·5	± 32·5 - 50
Output current :	0 - 1A	0 - 10A	0 - 1A	0 - 10A	0 - 1A	0 - 1A
Output resistance :	0·01 Ω	0·01 Ω	0·01 Ω	0·01 Ω	0·01 Ω	0·01 Ω
Output Z to 100 Kc/s:	0·2 Ω	0·2 Ω	0·2 Ω	0·2 Ω	0·2 Ω	0·2 Ω
Stability factor greater than :	200 : 1	150 : 1	200 : 1	150 : 1	200 : 1	200 : 1
Ripple and noise (peak to peak) :	1 mV	1 mV	1 mV	1 mV	1 mV	1 mV
Mains input :	90/130 Volts, 200/240 Volts. Permissible deviation ± 7%					
Dimensions :	12½" x 8" x 13" (33x21x33cm.)	22" x 10¼" x 16" (56x27x41cm.)	7¼" x 5½" x 5¼" (18x15x14cm.)	22" x 10¼" x 16" (56x27x41cm.)	Appx. 8" x 6" x 6" (20x15x15cm.)	Appx. 8" x 6" x 6" (20x15x15cm.)
Appx. weight :	25 lbs. (11·5 kg.)	55 lbs. (25 kg.)	7½ lbs. (3·5 kg.)	60 lbs. (27 kg.)	8 lbs. (3·8 kg.)	8 lbs. (3·8 kg.)
Price:	£95	£210	£55	£180	£60	£65

SOLARTRON

THE SOLARTRON ELECTRONIC GROUP LIMITED

THAMES DITTON · SURREY · ENGLAND · *Telephone :* EMBerbrook 5522

Telegrams and Cables : Solartron, Thames Ditton · International Telex : 23842 Solartron T.Dit.

Worldview

the month in atomic energy

Jason goes ahead

Britain's first training reactor and the nearest reactor to London is being built by the Hawker Siddeley Nuclear Power Co Ltd at their works in Langley, near Slough, Buckinghamshire. This is the 10 kW, graphite-moderated Jason, described and illustrated on p 100–101 last month. Construction was begun at the end of February and criticality should be achieved in September. It will be used for their own reactor research and also as a prototype.

Jason is a version of the Argonne National Laboratory's Argonaut and will be made to the same drawings, with some changes in detail in order to use British Standard components whenever possible. A major difference is the use of DIDO plates instead of the American MTR type. Already on the commercial market its purpose is training, research and isotope production in universities and other research organizations. As in all laboratory reactors, safety is inherent in the physics of the design and several mechanical devices are incorporated which ensure that nothing can cause a dangerous excursion.

Where the money goes

The 1959–60 Civil Estimates show that for the coming year nearly £M93 will be required by the AEA, some £M13 less than for 1958–59. The need for continued research is clearly shown by the grants to the Nuclear Research Institute which have been increased by nearly £M2 and AEA's participation in IAEA programme of operations makes it necessary to raise the allocation of funds by £18,000 payable to IAEA. The industrial potential of the Authority as a supplier of fuel and isotopes is expected to be much higher this year and the total income is anticipated to rise from £M13½ to £M31¼ and reflects the value of the fuel that will be required for the series of UK nuclear power stations at present under construction and overseas installations which will be drawing on the AEA for their fuel needs. With more fuel in demand and the mining facilities established the AEA's loans to uranium producers will be greatly reduced and will only be 1% of last year's assistance. With the increasing demand for AEA's materials isotope production and marketing is to be improved and the Radiochemical Centre at Amersham and the Isotope Division of AERE, Harwell, are to be combined into a single organization. This new unit will be known as the Radiochemical Centre and will be under the direction of Dr W. P. Grove.

RN goes American

On March 9 the First Lord of the Admiralty announced in the House of Commons that negotiations for an American reactor to be used in the first UK nuclear powered submarine had been satisfactorily concluded. Under the contract Westinghouse Electric Corporation will supply a complete set of Skipjack class machinery to Rolls-Royce. In addition, training, manufacturing techniques and inspection procedures will be given by the Americans to the Admiralty, Rolls-Royce and Rolls-Royce Associates. This nuclear propulsion will be installed by Vickers-Armstrongs (Engineers) into the *Dreadnought* hull being built by Vickers-Armstrongs (Shipbuilders). With the decision to use an American reactor, the design of the *Dreadnought*'s hull was modified to take into account the changed dimensions and information and assistance is being provided by Electric Boat who are responsible for building the *Skipjack* in the States. All the knowledge gained in this project will be available for use in connexion with British shore-based prototype which is being built at Dounreay and on which development will continue. It is the Government's opinion that by going to the States for assistance the *Dreadnought* will be completed much earlier and the final cost of construction will probably be reduced; development and research costs will be considerably reduced.

While construction is now at last proceeding for the first British nuclear powered submarine contracts for six more submarines have been placed by the US Navy, bringing the number of nuclear-powered submarines under construction or in operation up to thirty.

HOW THE 'DREADNOUGHT' WILL NOW LOOK—the USN 'Skipjack' on sea trials during March when estimated performance was fully realized

AEA reorganizes

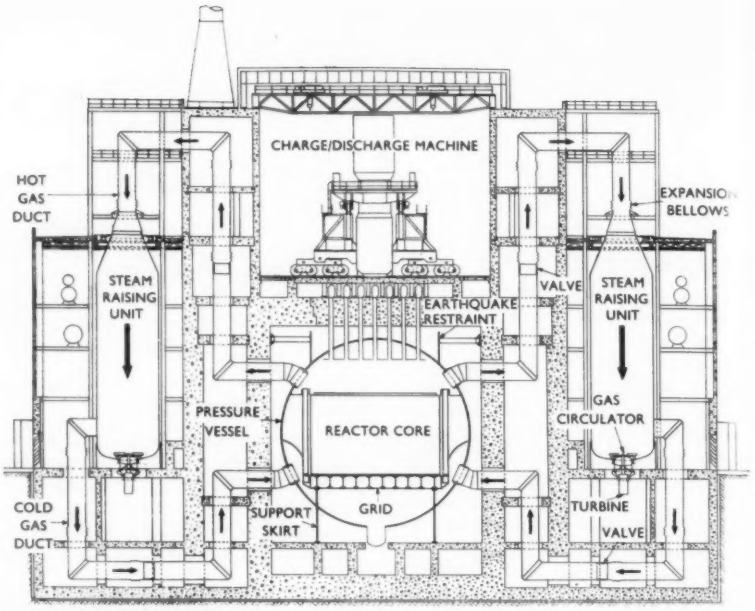
Lord Plowden is to become the new chairman of British Aluminium. On December 31 his term of office as chairman of the AEA which he has held since 1954 expires and he will take up his new appointment early in 1960. At the same time he will become vice-chairman of Tube Investments.

As the Industrial Group has grown so large it will be divided into two groups on July 1. One, the development and engineering group will be directed by Sir William Cook as 'Member for Development and Engineering' and will be responsible for designing and constructing major projects and the Capenhurst,

Dounreay, Springfields and Windscale establishments. The other group, production, will be headed by Sir Leonard Owen as 'Member for Production (Designate)' and this group will control the AEA's factories such as Calder Hall and Chapelcross.

The Director of AERE, Harwell, Sir John Cockcroft has been appointed by the Queen in Council as a member of the Court of the University of London.

Due to the Atomic Energy Establishment, Winfrith, coming into being AEA have made staff changes in the research group. Mr D. W. Fry at present Deputy Director at Harwell has been appointed Director of AEE, Winfrith, and Dr F. A. Vick, OBE, has accepted an appointment as Deputy Director at Harwell. At present he is Head of the Department of Physics at the University College of North Staffordshire.



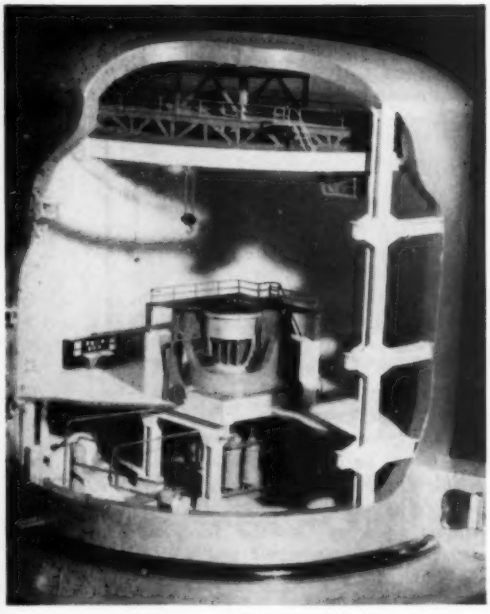
EARTHQUAKE-PROOF. Section of GEC's modified Hunterston design, with top loading and turbine driven blowers, for Japan—see Tidying GEC details

BRAZIL

Power in two stages

The Brazilian Government has adopted a short and medium-term programme of nuclear power plants although there are untouched sources of hydro-power yet to be developed; these may possibly delay the installation of some nuclear stations. The Central Government are at present considering proposals for a 30 MW nuclear power station for Jurumirim. Interest and even competition exist between the individual state authorities and the State of Rio de Janiero is reviewing the proposals put forward by the Mitchell Engineering Ltd for a 20–35 MW power plant. The State of Parana has already enlisted the services of the same company and discussions are progressing between Mitchells and the States of Sao Paulo and Rio Grande do Sul.

UK TRAINER SHOWN IN US. Model of the Vickers design study for a 5 MW heavy water moderated research and training reactor which will be shown at the Atomfair in Cleveland during the Nuclear Congress, April 5–10



DENMARK

Riso's get-together

OEEC and the Danish Atomic Energy Commission are jointly organizing a symposium to be held at the DAEC's Riso research centre near Copenhagen between May 25 and 28. Directed at health physicists at atomic energy centres the purpose of the symposium is to review the scientific and technical aspects of health physics applicable to radiation protection, contamination and emergency measures. Canadian, European and US atomic authorities are cooperating in the presentation of this symposium.

FRANCE

The Plan at half-time

Now over 2 years through her second five-year nuclear energy plan (1957–61) the Commissariat à l'Energie Atomique is currently employing directly about 4500 persons. The main feature of the first two years has been the building of the third Centre d'Etudes Nucléaires, at Grenoble, where a 1200 kW pool—MELUSINE—is now in operation.

Satisfactory progress has been reported from all activities and it has now definitely been decided to build a gaseous diffusion plant. This will be at Pierrlatte and the plant is expected to start production by the end of 1962. During the current year some of the highlights programmed are:

REACTORS

G2–G3. It's expected to raise G2's output this year and to bring G3 into commission about midsummer. The gas inlet temperatures have been raised to improve the Wigner situation.

Gas-cooled. Aim is raising of specific power output and heat transfer in EdF's type of reactor. Wigner studies also figure in programme.

High-temperature. It's hoped to start work on BRENDA this year if problems of beryllium behaviour under radiation and heat can be solved. If they can't, water or graphite will be used as moderator. Fuel is ceramic-clad oxide.

Heavy-water. Design study for 100 MWe gas-cooled plant started last year will now be reworked in more detail.

Fast-breeder. Studies are still proceeding on the RAPSODIE project (10 MWt). No site has been announced but it's hoped to have it critical by 1962. Design will owe more to Fermi than Dounreay. Fuel 235 + Pu.

MATERIALS

Ceramics. Manufacture of uranium oxides and carbides has been perfected and now irradiation trials are to take place.

Plutonium. Alloys have been developed and irradiation tests are in hand. Pyrometallurgical process for fast reactor elements will be developed.

Heavy water. The Toulouse liquid hydrogen distillation plant is expected to come into operation in 1959.

PRODUCTION

Raw materials. About 800 tons of uranium metal should be produced from concentrates—500 from Le Bouchet and 300 from the new plant at Malvézy.

Plutonium. G1 will continue in production with efforts to improve product quality. When G2 and G3 get into full production G1 will be used only for research.

HUNGARY

Expansion at Debrecen

Another stage in the expansion of the Hungarian Academy of Science's Nuclear Research Institution is marked by the completion of a large laboratory. This building costing some £M¼ is mainly for housing an 80 MeV cyclotron and a special spectograph. To accelerate the combined research and training programme the next stage in construction at this establishment is to be in the building of an experimental reactor; this facility will enable Debrecen's earlier neutron studies to be continued without facilities having to be provided by other centres, as is the case at present.

JAPAN

Tidying GEC's details

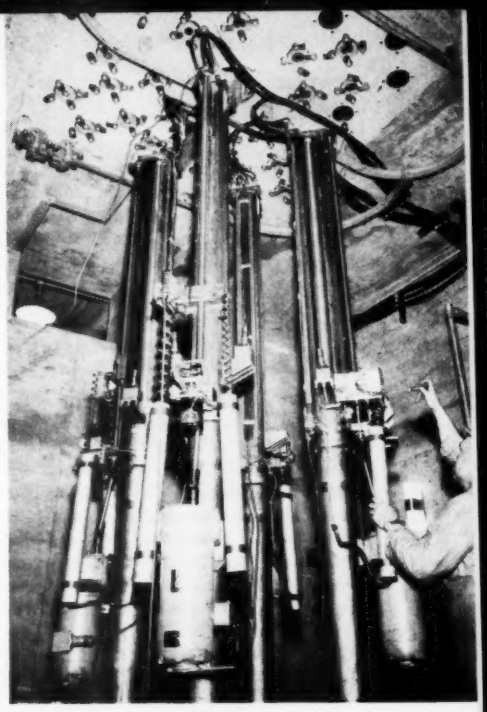
At the end of March Mr Tamaki Ipponmatsu, vice-president of the Japan Atomic Power Generating Company, came to England to negotiate a technical assistance agreement with the AEA on fuel for the proposed nuclear power station. Discussions are already well advanced with GEC (*Worldview*, March) and the company hopes that it will receive a letter of intent from Mr Tamaki Ipponmatsu whilst he is in this country. GEC is the only company negotiating with the Japanese under an 'exclusive' arrangement and the proposals they have put forward are for an improved and modified version of the nuclear power station they are building at Hunterston. The changes made to the basic design are to meet the earthquake requirements in Japan. Fuel charging will be carried out from the top instead of the bottom of the reactor so as to have a low as possible centre of gravity and the reactor vessel will have top restraining supports as well as the normal support skirt. To meet possible emergency shut-down requirements during or after an earthquake, individual control drives are to be installed and are supplemented by emergency shut-down facilities which will operate under all conditions up to a 45° tilt of the reactor. These supplementary services are responsive to all the normal reactor shut-down systems as well as being seismically tripped. Another improvement incorporated by GEC is in the circulating gas circuit where turbine drives replace the earlier electrical variable speed units. As soon as GEC get the go ahead from the Japanese they will be able to immediately start operations in Japan through the consortium of fourteen Japanese companies known as the First Atomic Power Industrial Group with whom they have entered into long term licensing arrangements.

UNITED STATES

Where does AEC stand?

In recent months the AEC, the Ad Hoc Committee, the Joint Congressional Committee on Atomic Energy (JCAE) and US Industry have all with typical American outspokenness told each other what the future nuclear energy policy should be. The Ad Hoc Committee, primed by AEC has reaffirmed that costs of nuclear power production should be reduced, US proposals competitive for nuclear power plants overseas and that the fullest use of uranium and thorium, especially by breeding, should be made. Taking these recommendations AEC proposed budget for the 1960 fiscal year included $M30 for not more than four experimental power reactors either by direct government construction or in cooperation with industry. Against this development, the Commission recommended cancelling the liquid metal fuel reactor experiment and the Chugach cooperative project, modifying the Kaiser-ACF project and the postponement of the Hallam sodium-cooled project. The total funds required for the AEC programme was over $M115. This immediately came under fire from the JCAE and supported by industry wanting greater government financial support, indicated that the power plant programme should be much greater and that at least three large projects should be added. The AEC retaliated by submitting a revised appropriations bill adding a new section. This provided for the use of power generated by the Commission's installations and the participation of utility organizations in the projects. Plans for a heavy water moderated power reactor together with an advanced design capable of utilizing superheat were introduced and postponement of the Hallam project withdrawn. This programme brought the financial requirements to over $M159, including $M14 for Euratom cooperation.

While in the main Industry has indicated that an even more comprehensive policy should be undertaken by the AEC including several proposals for nuclear-powered mercantile vessels, the US officials have indicated that at this stage they do not see the need for additional projects. This outlook may well lead to the American nuclear industry pursuing a more aggressive policy of its own, especially in markets outside the jurisdiction of the AEC, with in due course, the relative decrease in importance of the Commission.



TREAT'S CONTROLS PREPARED. Checks being made to the solenoid-operated latch of a control rod drive in preparation to the first start-up

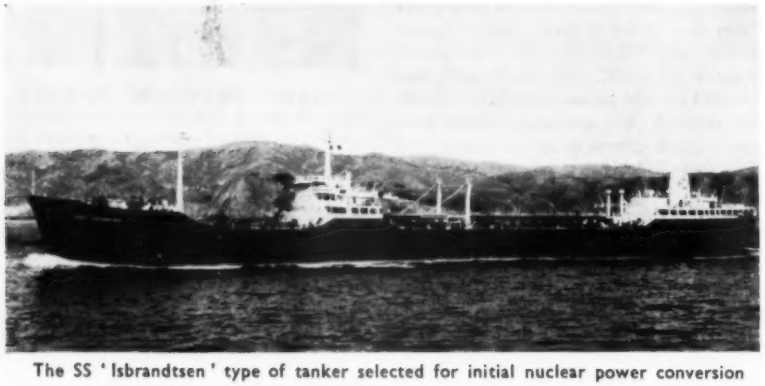
TREAT achieves criticality

AEC's Transient Reactor Test Facility (TREAT) at the National Reactor Testing Station, Idaho Falls, went critical on February 23. This unit built by Argonne's Reactor Engineering Division is designed to produce short, extreme pulses of energy resulting in high temperature and it will be used to study meltdown samples of fuel elements and components intended for use in fast reactors. It is interesting to note that the graphite blocks used as a reflector are from the world's first two reactors, Chicago Pile 1 and 2. At present loaded with 146 fuel elements, space is provided for loading up to a total of 361 assemblies giving great flexibility for experimental arrangements. These assemblies, made by Argonne's Metallurgy Division in conjunction with the Great Lakes Carbon Co, are nearly 9 ft in length and consist of an upper and lower graphite section and a 4 ft uranium oxide-bearing graphite central section. The central fuel section contains six 8 in. fuel blocks canned as a unit in zirconium alloy. The upper and lower end sections are canned in aluminium. Eight control rods are driven pneumatically through four drives and the rods are capable of being lowered through a 4 ft stroke in 90 milliseconds. Each rod of tubular form

is made up of three sections; a nickel-plated carbon steel section containing the neutron absorber of boron carbide; a graphite-filled zircaloy section; and a graphite-filled oxide-coated, carbon steel portion connecting to the drive mechanism.

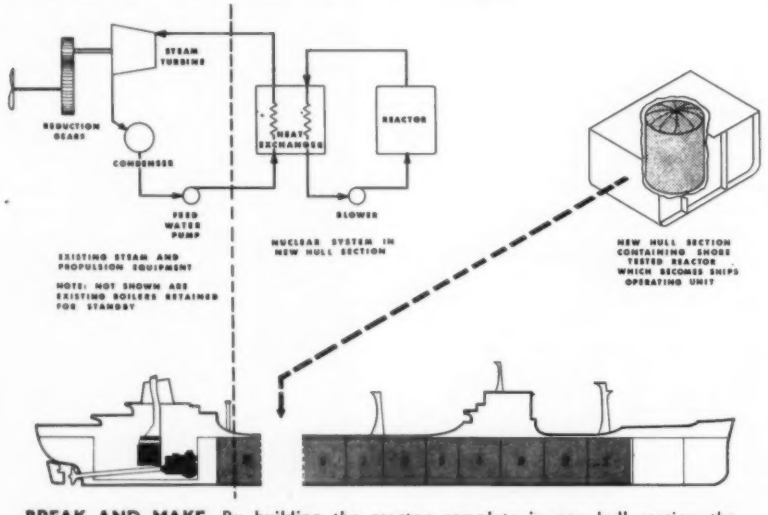
Rapid marine conversion

The new Ford Instrument/Isbrandtsen/Maryland group set up in February to build nuclear powered merchant vessels have announced their plans which will enable rapid progress to be made. The proposals are that instead of a land-based reactor being built first and then constructing one for the vessel, one reactor will be built in a newly-constructed cargo section of the vessel's hull and a whole vessel will have to be built, the reactor will be tested in its normal operating environment, and when brought into service, the normal propulsion machinery will be used. The first type of vessel to be dealt with in this way will be the 32,791 ton tanker SS Hans Isbrandtsen. The reactor will be of the helium-cooled graphite-moderated type having stainless steel clad uranium dioxide pellets fuel giving a gas exit temperature of 950°F. Superheated steam at 640 psi and 850°F will be generated. The gas-steam cycle has been chosen as it is not affected by pitch and roll; steam reaching the turbine will not be radioactive; and there will be no necessity for the discharge of radioactive wastes. On basis of the estimated development costs being $M5 and construction including



The SS 'Isbrandtsen' type of tanker selected for initial nuclear power conversion

will be towed to a remote location for testing. When the tests have been successfully concluded the section, complete with its reactor will be docked and substituted for an existing section in the ship. The advantages of this method are in addition to the saving of having only one reactor are that one section and not testing $M10 and present net fuel costs, the nuclear fuel would be competitive with bunker fuel oil by the third or fourth core loading. In addition the cargo oil capacity would be increased by approximately 5% which would largely offset the early nuclear fuel cost by raising the payload.


STEAM TURBINE
REDUCTION GEARS
CONDENSER
HEAT EXCHANGER
REACTOR
FEED WATER PUMP
BLOWER
EXISTING STEAM AND PROPULSION EQUIPMENT
NOTE: NOT SHOWN ARE EXISTING BOILERS RETAINED FOR STANDBY
NUCLEAR SYSTEM IN NEW HULL SECTION
NEW HULL SECTION CONTAINING SHORE TESTED REACTOR WHICH BECOMES SHIPS OPERATING UNIT

BREAK AND MAKE. By building the reactor complete in one hull section the vessel can be converted simply by removing one storage section and replacing it with the reactor

———VENEZUELA———

Suspension ended

Construction of Venezuela's first rector suspended in January 1958 due to change of Government has now been resumed. Completion of this 30 MW GE Pool reactor at the Institute for Neurology and Brain Research at Caracas will be made by the end of this year. The project including buildings and laboratories when finished will have cost $M5·4 of which the US has given $300,000 towards the $600,000 required for the reactor.

———INTERNATIONAL———

US proposals for Euratom

The Joint Research and Development Board of Euratom and the US will begin its meeting early in April. Under the terms of the cooperative agreement which came into effect on February 18 between the European Community and the US this programme for this board is centred upon industrial objectives.

Site sought in Europe

The second general report issued by Euratom stresses the need for rapidly establishing a Community Research Centre. As it has been decided that a new centre would take too long to build consideration is being given as to whether any of those already in existence might be put wholly or in part at the disposal of Euratom. The programme being followed by the Commission includes heavy water reactors with one prototype to be built, material-testing reactors and plutonium. Other research work is being contracted out to bodies outside the Commission and the first contracts will deal with radiobiology, plutonium and controlled nuclear fusion; negotiations covering the latter are already in force with the French Atomic Energy Commission and the Max Planck Institute at Munich. Basic protection standards against radiation hazards have been issued and on March 12 Euratom brought into force the first part of its security system.

Euratom goes commercial

The first meeting of the Consultative Committee of the Euratom Supply Agency was held in Brussels on February 24. Etienne Hirsch, President of the Commission, attended and M. F. Ippolito was elected President and F. Beckenbaurer together with H. C. J. H. Gelissen were elected Vice-president of the Agency.

The Supply Agency, under the control of the Commission, is responsible for the supply of metal ores, raw materials and special fissile materials in accordance with the principle of equal access to resources for all the Community.

While under normal conditions such as exist at present the Agency's activities are confined to those 'of a good agent' it will in the event of an unbalanced market act as a regulator and in exceptional cases will apply vigorous conditions of control.

WORLDBRIEFS

● **Antarctica.** Within the next three years the US will install nuclear power stations at each of its four Antarctic bases.

● **Australia.** By mid-1959 the Australian Institute of Nuclear Science and Engineering which held its inaugural meeting last December will be established in its headquarters at Lucas Heights under the presidency of Dr D. O. Jordan of the Adelaide University.

● **British Guiana.** After further discussions Mitchell Engineering have been asked to prepare a proposal for a $M15 nuclear power plant and the Government's consulting engineers have been instructed to go ahead with detailed negotiations.

● **East Germany.** The Wismut Corp a joint East German-Soviet enterprise employs some 200,000 workers on uranium mining and at present the output of uranium oxide is running at approximately 200 tons per annum.

● **Germany.** The new nuclear research centre, the Hahn-Meitner Institute, in West Berlin was formally opened on March 14.

● **Iraq.** On March 9 IAEA had deposited with it Iraq's instrument of ratification of the Statute of the International Atomic Energy Agency. Since July 1957 when IAEA came into being, the statute has been ratified by over sixty Member States.

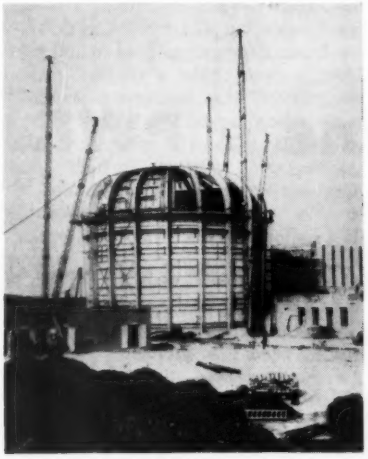
● **Italy.** Ing. Gino Martinoli has retired from the office of Managing Director and Director General of AGIP-Nucleare although he will remain a member of the Board. Ing Mario Comparini, formerly Director General of SAIPEM, is the new Director General of AGIP-Nucleare.

● **Scandinavia.** During March Dr J. M. Fletcher, Deputy Chief Scientist at AERE, Harwell, carried out a lecture tour of Finland and Sweden for the British Council. He gave talks to specialist and non-specialist audiences on British achievements in the peaceful uses of atomic energy.

● **South Africa.** The South African Atomic Energy Board (SAAEB) is investigating the commercial potentialities of producing heavy water for export. Production techniques have been studied by senior SAAEB engineers during an eighteen months visit to Harwell.

● **United Kingdom.** The Annual Dinner of the Nuclear Engineering Society was held in Warrington on March 2, Sir Donald Perrott, AEA member for Finance and Administration said that the Authority's manpower had risen over the past five years from 18,000 to 35,000. Among those present at the dinner were Sir John Cockcroft, Dr H. S. Arms (English Electric), Mr J. W. Ashley (Atomic Power Construction), Dr K. J. Wootton (GEC-Simon Carves), and Mr S. A. Ghalib (AEI-John Thompson). Mr R. Vaughan (Nuclear Power Plant) was unable to attend.

● **United Kingdom.** Chapelcross is the first nuclear power station in Scotland to feed electricity into the national grid. The steam circuit of the first reactor which went critical last November was passed to the turboalternators on February 25; this was earlier than originally scheduled.



● **Holland.** Construction of the 20MW ORR-type reactor by ACF Nuclear Products is well forward at Petten. The cooling water will be drawn from the North Holland Canal and discharged into the nearby North Sea.

● **United Kingdom.** AEA have awarded a contract for a radioactive caesium recovery plant to W. J. Fraser & Co Ltd who will be responsible for the design and construction. The caesium will be recovered from the highly active waste materials produced in processing irradiated fuel. A considerable portion of the plant will be fabricated at Fraser's Monk Bretton works.

● **United States.** On February 28 the Atomics International L77 10 W reactor of the University of Wyoming in Laramie went critical. This laboratory unit will be used for a series of experiments to demonstrate basic reactor principles for engineering, chemistry and physics students.

● **United States.** Nearly 11 million kilowatt hours of electrical power have been generated from heat produced by the Sodium Reactor Experiment (SRE) since it began power operations in July 1957. SRE is operated by Atomics International for AEC and the steam temperature of 770°F achieved is claimed to be the highest yet produced from a nuclear heat source.

● **United States.** Incorporating additional containment for the reactor AEC has now approved the site for the Piqua organic moderated nuclear power plant. It will be located some 200 yd from the Piqua municipal power station.

● **United States.** AEC have selected the Martin Co's proposals for a pressurized water reactor, moderated by light water and fuelled with enriched uranium producing 1000 kW of electricity and 2000 kW of heat as one of the series to be developed under the Army Nuclear Power Programme.

● **West Germany.** The British atomic industry is being strongly demonstrated at the Hanover Industries Fair between March 26 and April 5. Led by the Board of Trade and the Nuclear Energy Trade Association the case for British nuclear power stations and the extensive experience in reactor fuel production is well advanced. Other fields of the atomic industry, including isotopes, are also represented.

● **West Germany.** All three British tenders for a 100 MW nuclear power station for Baden-Württemberg together with one from the American GEC have been rejected. The German study group is now considering three American proposals; from Westinghouse Electric, Babcock & Wilcox and Atomics International. The reasons given for the rejections were higher cost of installation and less favourable terms for the supply and return of fuel. An advantage of accepting an American project would be that funds under the Euratom agreement would be available from the US.

● **Yugoslavia.** During March two experts from the IAEA visited the Boris Kidric Institute, Yugoslavia's atomic energy centre, at Vinca near Belgrade. Both from the Agency's Reactor Division, these members studied the pattern of circumstances which led to the accident last October to a group of young scientists when they were subjected to high doses of radiation.

● **International.** On March 23 the agreement for the instructional project 'Dragon' was signed at the Paris headquarters of the OEEC. The high-temperature gas-cooled reactor for this project will be erected at the Winfrith establishment.

● **International.** The Bagdad Pact's nuclear centre has now been moved to Teheran, Iran, and the new director is H. A. C. McKay from Harwell.

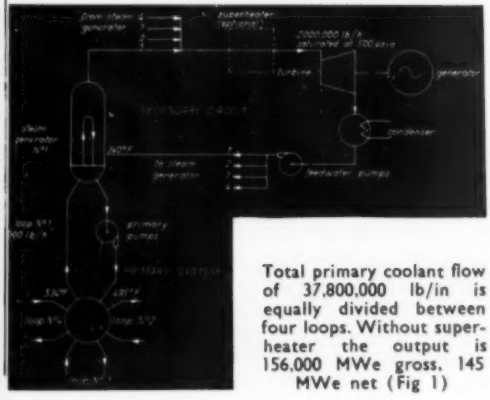
In 1957, ACEC, probably the largest electrical plant manufacturers in Belgium, concluded a licence agreement with Westinghouse for know-how on their PWR and joined up with the boiler makers Cockerill-Ougrée to exploit it. They have now produced a detailed design for a 145 MWe reactor which is at present being tendered for European projects. Here is the first authentic account to reach Britain

Belgium plans a PWR for Europe

by CHARLES GERARD
Nuclear Division, Ateliers de Constructions Electriques de Charleroi

SINCE THE VALIDITY of the pressurized water reactor concept has been proved by the successful cruises of the *Nautilus* and the operation of the Shippingport power station, a growing family of reactors of this type has now been designed and developed. Although all the designs incorporate the same general principle, they can differ from the basic plant concept, just as gas-cooled reactors by commercial companies are different from the Calder Hall station.

In this design, the core output is 525 MWt, which produces in the shell side of the steam generators 2,000,000 lb/h of saturated steam at a pressure of 500 psia. Expansion of this steam flow in the turbine yields a 156 MW gross electrical output and the condensed water, after being reheated, is returned to the boilers at a temperature of 340°F. The net electrical power of the plant amounts to 145 MW.



Total primary coolant flow of 37,800,000 lb/in is equally divided between four loops. Without superheater the output is 156,000 MWe gross, 145 MWe net (Fig 1)

In order to increase the steam temperature up to 1000°F at the expense of a slight pressure drop, a coal-fired superheater can be added between the boilers and the turbine. The net electrical output is accordingly increased and reaches 240 MW.

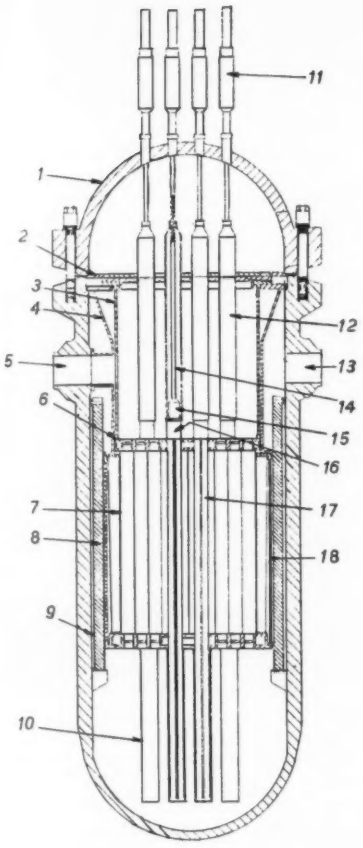
The reactor vessel is a right cylindrical container fitted with a hemispherical bottom and closed by a removable head almost identical in shape with the bottom (figure 2). This has an internal diameter of 109 in. and an overall height of 31½ ft. The cylindrical wall, which is 8½ in. thick, is made in carbon steel, and the same material is used for the bottom and the head, which are respectively 5 in. and 8¼ in. in thickness. All the inside surfaces are clad with stainless steel. The design pressure is 2500 psia and the cold test pressure is 3750 psia.

The primary coolant enters the vessel through 20 in. pipes, and flows downwards along the thermal shield. After reversing its course, the water flows upward through the reactor core and leaves the reactor through four 20 in. outlets. The thermal shield is a stainless steel cylinder resting on support lugs attached to the vessel wall. The core support barrel also serves as a thermal shield (figure 3). These shields absorb gamma rays from the core, thereby reducing the heat generated inside the vessel walls.

Enriched dioxide chosen

The reactor vessel is placed in the centre of an annular, water-filled neutron shield tank. This serves the dual purpose of supporting the reactor and reducing the radiation intensity.

The fuel assemblies are held in place between two stainless steel grids and are contained inside a baffle which channels the cooling water in the core itself. The water between baffle and barrel acts as a neutron re-



The reactor vessel is 31½ ft overall height with 8½ in. carbon steel walls. Diagram shows: 1. reactor vessel head 2. core hold-down ring 3. upper core support barrel 4. lower core support barrel 5. outlet nozzle 6. upper core support plate 7. core baffle 8. thermal shield 9. lower core support plate 10. control rod shroud 11. control rod drive mechanism 12. control rod guide tube 13. inlet nozzle 14. control rod drive shaft 15. control rod shock absorber 16. control rod stop 17. control rod 18. core barrel (Fig 2)

flector. The grids and core elements are supported by large cylinders provided with flanges resting on a ledge just below the vessel closure.

The core contains approximately 60,000 lb of uranium oxide, enriched to about 3 atom per cent in the fissionable isotope U-235. Uranium is supplied in the form of hexafluoride UF_6, which is converted into uranium dioxide, compacted and sintered into cylindrical pellets and introduced inside stainless steel tubes, 0·3 in. o.d. The tubes are sealed with welded caps and assembled in a square lattice of 20 × 20, held together by end plates. Some rods are purposely omitted along the edges of the bundle in order to provide free slots (figure 3), thereby reducing the number of rods from 400 to 380. Each fuel assembly has a total length of 120 inches and has a square cross-section, 7½ × 7½ in. When the fuel assemblies are arranged to form the core, the free slots form 32 cross-shaped perforations to allow the insertion of 24 cruciform control rods and 8 shim rods of the same shape.

The use of uranium in the oxide form was decided on after careful evaluation. Uranium metal is more efficient from the nuclear point of view and it also has better heat transfer characteristics. However, the oxide is a refractory material with the advantage of a very high fusion temperature. It is very corrosion resistant in hot water and has the important quality of retaining fission products, which considerably reduces the contamination of the primary coolant in case of a cladding failure.

Stainless steel cladding

In any case, these failures must be kept to a minimum and the choice of a cladding material is of paramount importance. In Shippingport, zircaloy-2 was used to a very great extent. However, numerous tests conducted in the meantime have shown that stainless steel can also be used: it has higher thermal neutron cross-section, but better mechanical properties and its price is much lower.

Either hafnium or an alloy of several metals, such as silver, cadmium and indium, forms the active section of the control rods. Below this there are extensions of identical shape which act as guides and have to fill the slots when the poisoned section is withdrawn, otherwise there would be holes through which part of the coolant flow could by-pass the fuel assemblies. As the extensions have to remain in the core during operation, they are made of low neutron cross-section material, zircaloy-2.

The 24 control rods are located in the central portion of the core, the remaining 8 slots being used to accommodate shim elements, since rods in the outer positions would have low effectiveness. No reactivity effect being desired from the shim elements, they are also made of zircaloy-2.

Four-loop primary system

The primary coolant flow, which amounts to 37,800,000 lb/h, is equally divided between four loops (figure 1), when all the pumps are in operation. The water, under 2000 psia pressure, enters the reactor at a temperature of 495°F and leaves for the steam generators after gaining 39°F. The coolant is circulated under a total head of 80 psia. Each loop, made of 20 in. dia pipes, is equipped with stop valves and a by-pass line (figure 6). The valve in this line is interlocked with the isolation valves in order to prevent a shock loading of the pumps, should the stop valves inadvertently be closed. A check valve is mounted in each loop to prevent backflow in case of a pump failure or a partial loss of auxiliary power.

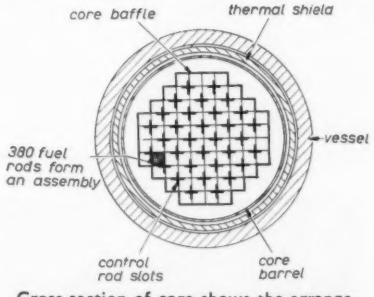
It is very important to keep the water in a very high degree of purity, if its radioactivity is to be maintained as low as possible. Therefore, the components or pipe surfaces in contact with primary coolant are made in stainless steel, to prevent corrosion. The very thick walls, like those of the reactor vessel, are made in carbon steel, with an inner stainless steel lining.

In order to make allowance for thermal expansion in the main coolant piping, the different pieces of equipment are suspended by spring-loaded supports, which can be adjusted to a predetermined tension level.

Vertical shell generators

The steam generators are of the vertical shell and tube design (figure 4). They are provided with an integral steam drum, and their approximate height is 37½ ft, diameter 84 in. The primary coolant enters and leaves at the bottom of the generator vessel. It is circulated through stainless-steel U-shaped tubes, and separated from the secondary water-steam mixture by a tube sheet.

Feedwater at 340°F enters the boiler section near the top of the tube bundle jacket. It flows downward



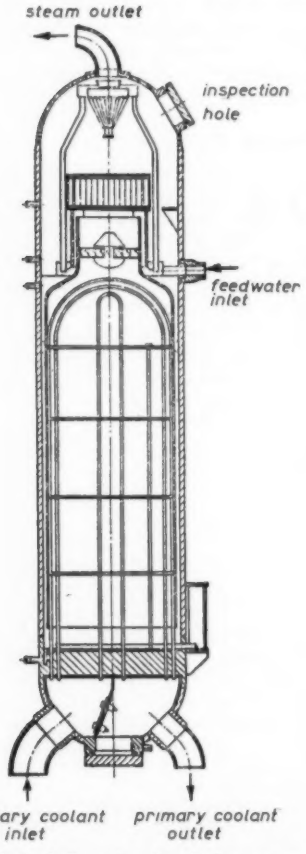
Cross-section of core shows the arrangement of the 7½ in. square fuel assemblies to give 32 cruciform perforations for the control and shim rods (Fig 3)

along the vessel walls before being raised up in the tube bundle, where boiling occurs. The steam and water mixture is forced through a fixed vane type steam separator, a chevron type drier, and a centrifix purifier. The steam, which contains less than 0·25% humidity, is lead by a common line to the turbine, while the water which has been centrifugally separated flows downward to be mixed with incoming water.

The canned motor pumps used in the primary system are of the vertical

type, with single stage radial flow, bottom suction and horizontal discharge. They are designed for a 2500 psia pressure and tested under 3750 psia. Their nominal capacity is 20,000 gpm, and the net positive suction head (NPSH) required is 150 feet. They must be fed with 125 gpm of cooling water at 100°F. Their power requirement when running hot is 1400 kW, 50 cps, 3 kV voltage line. Figure 5 shows the parts of a canned motor pump being assembled. This was made to circulate water at a temperature of 625°F and under a pressure of 2200 psia.

The *pressure control system*, shown in figure 6, maintains the nominal pressure of 2000 psia in the primary



Vertical shell and tube design steam generators are 37½ ft high. Feedwater enters the boiler section at 340°F (Fig 4)

loops and limits to an allowable range the pressure variations. The main item in this system is the pressurizer vessel, which is nominally half-filled with water. Saturation conditions are automatically maintained by immersion type electric heaters located in the lower portion of the vessel. The pressure is transmitted to the primary system by a pipe connecting the pressurizer bottom to one of the loops.

On decrease of the reactor average temperature and contraction of the coolant, usually as a result of increased generator power demand, water flows out of the pressurizer and through the standpipe to the primary loops, while part of the water remaining in the vessel evaporates. On the other hand, on increase of average temperature and expansion of the coolant, water flows into the pressurizer where it compresses the steam space. Several means are provided to take care of excessive pressure conditions: first, a spray line is opened at the top of the pressurizer to condense part of the steam; electrically-operated relief valves open at a pressure of 2400 psia; and finally, code safety valves prevent the pressure from exceeding the design value of 2500 psia.

Volume control important

The *charging and volume control system* has numerous important duties:

1. filling of the reactor and loops, associated with refuelling and maintenance

2. operating the hydrostatic test of the primary system at a pressure of 3750 psia

3. bleeding and feeding primary water at variable rates, providing a means for adjusting the liquid level in the pressurizer

4. care of coolant expansion or contraction during startup and shutdown operations—note that the water density at 515°F and 2000 psia is only 0·76

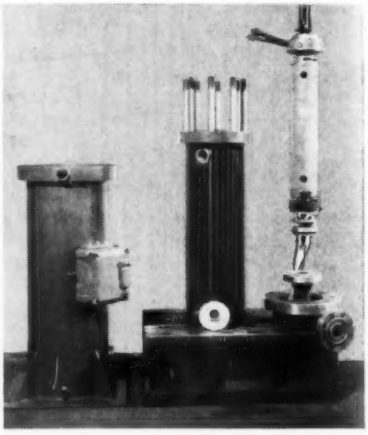
5. quenching in the surge tank of steam discharged from the relief and safety valves of the pressure control system.

Water is bled from the main coolant system at a temperature of 495°F, passes through a regenerative heat exchanger where the temperature is reduced to about 250°F, and flows in the low pressure surge tank past motor-operated valves. This tank is normally half-filled with water. It is equipped with a spray line in case of a failure in the regenerative heat exchanger, and with quenching orifices and safety valves. Charging pumps feed the water back to the primary system through the regenerative heat exchanger. The feeding and bleeding rates are controlled by the water level in the pressurizer.

The *chemical addition system* injects chemical solutions into the primary coolant to reduce corrosion and to control the pH of the water.

The *chemical shutdown system* is used for pumping a neutron absorbing boron compound into the reactor. This is necessary to supplement the rod control for plant cool-down, because, as will be seen later on, the rods have been designed to handle the reactivity changes due to burnup and build-up of fission products only.

The *purification system* has to maintain very high purity standards in the primary coolant. The make-up water may contain some impurities



Shown here during assembly, the vertical canned motor-pump design chosen for the primary coolant has single stage radial flow, bottom suction and horizontal discharge (Fig 5)

and, despite the generalized use of stainless steel, some corrosion products are present in the reactor coolant. In addition it is possible that a small percentage of fuel rods may develop leaks and allow some of the fission products to escape in the coolant. These impurities are undesirable since they could cause an excessive radioactive level in the primary loops and reduce the core and steam generator heat transfer characteristics. The boron chemicals injected for cold shutdown have also to be cleaned from the primary water.

Safety and cooling circuits

Purification is accomplished by four demineralizers, two of the mixed bed type, and two of the anion type for boron removal. The water to be treated is bled from the low pressure surge tank at a temperature lower than 130°F to prevent destruction of the demineralizer resins. After purification, the liquid is returned to the same tank.

The *safety injection system* can provide great volumes of borated water in case of a serious accident in the primary system. Such an eventuality will be discussed later on, in the section dealing with the security problem.

The *decay heat removal system* is

required to remove the heat produced by decay of fission products in the core during shut-down periods. It consists of piping and valves which allow it to circulate fresh water in the reactor vessel and to cool it in heat exchangers located in the sytem described next.

The *component cooling system* supplies cooling water to plant components such as the main coolant pumps, the control rod drive mechanisms, the coils immersed in the neutron shield tank and in the fuel storage pit, the decay heat removal system, and the low pressure surge tank. Different circuits are provided depending on whether the cooling water is radioactive or not. Even if it is not, special care must be taken to limit the contamination if, for instance, a leakage of radioactive water should occur through failure in a heat exchanger.

The *vent and drain system* provides suitable facilities to eliminate from the waste disposal system all radioactive gases and liquids during filling, draining, flushing and normal operation of the main coolant system.

The *sampling system* provides means for collecting samples from all the systems and primary loops which are taken to an especially equipped laboratory. Here several measurements, such as conductivity, pH, and chemical concentration are made. These analyses give information on the poisoning of the demineralizer resins, the purity degree of primary water, the corrosion rate, and the level of radioactivity.

Power control and scram

The essential duties of the control rods are to regulate the power level, and to scram the reactor in case of emergency. They are moved vertically by individual mechanisms of the magnetic jack type which are welded to the reactor vessel head in order to provide hermetic sealing of the primary system.

With a new and clean core, criticality is reached with the rods deeply lowered between the fuel elements. They are lifted gradually to compensate for fission product build-up, and for fuel depletion. They have also to counteract short period variations in xenon concentration after changes in power level.

Introducing all the control rods in the core is sufficient to stop the chain reaction at normal operating temperature, i.e. 515°F. But it is impossible to cool the primary system down to ambient temperature because the reaction starts up again when the temperature is allowed to decrease. This explains why it is necessary to inject borated water in the reactor vessel in order to supplement the control rods for complete shutdown.

The negative reactivity coefficient provides an intrinsic and reliable means for adjusting the station power level. Suppose the generator has to supply more power to the grid. The steam flow is increased, and also the thermal power transferred to the secondary circuit through the boilers. The primary coolant enters the reactor at a lower temperature, and this adds reactivity into the core, with the result that the temperature of the water in the hot leg is increased. The reverse process happens when the turbine load is decreased. Thus the mean coolant temperature always remains constant, while the temperature difference between cold and hot legs adjusts itself in order to match the power absorbed by the grid.

The cost of power from the ACEC PWR

Assuming 8% capital charge (5% interest rate), 20 years' amortization, and 75% load factor, company cost estimates in pence per kWh mates in pence per kWh are:

Capital	0·38
Operation	0·07
Fuel	0·25
TOTAL	0·70

The essential duty of the nuclear instrumentation is measurement of the neutron flux level and the period of the reaction. Detectors are located in thimbles distributed around the reactor vessel in the neutron shield tank. Due to the very large range of neutron fluxes between source and power level, the circuits are divided in two categories: start-up and power range instrumentation.

The start-up equipment computes and indicates on the control board the level and rate of change of the neutron flux from the source level up to 3% of full power. This provides the operator with the necesary information for manual start-up. The circuits are divided into two ranges: source range and intermediate range. In each, duplicate channels are provided for increased reliability. The start-up channels also send a 'stop rod' signal when the flux rate of change exceeds a preset value.

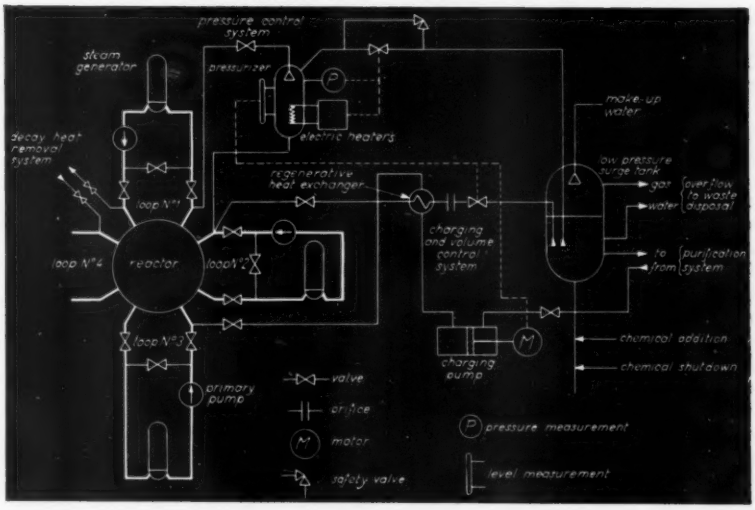
Between 3% and 150% of nominal power the power range instrumentation is used consisting of three identical ionization chamber channels. They provide an indication of the neutron flux level and also a shut-down signal when the flux is higher than a preset value. To eliminate the possibility of reactor power interruption due to some malfunction in one channel, control rod insertion is initiated only upon the occurrence of two simultaneous shut-down signals.

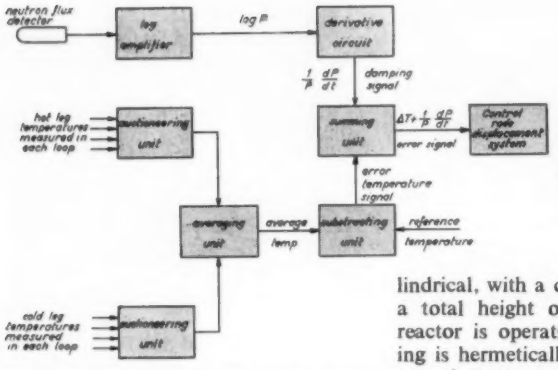
Primary coolant variables

Conventional instrumentation is used for evaluating the essential parameters of the primary coolant: temperature, flow, pressure, and also the liquid level in the pressurized vessel. In each loop, a thermometer is located at the reactor vessel outlet, and another at the steam generator outlet. These two instruments measure respectively the hot leg and the cold leg temperatures.

In normal operation, the effect of the negative temperature coefficient of reactivity is sufficient to adjust the reactor power level. The control rods are moved about once a day to compensate for fuel depletion and build-

Sketch of reactor auxiliary systems shows the stop and isolation valves in the primary loops and by-pass lines to the pressure control system (Fig 6)





The average temperature control system is designed to maintain the primary coolant at 515°F ± 3°F (Fig 7)

up of poisons. After large power variations, rod displacements are much more frequent—up to one or two adjustments a minute—due to the rapid variations in xenon concentration. These adjustments are initiated by the average temperature control system, the block diagram of which is given in figure 7.

This system is designed to maintain the primary coolant temperature at 515°F plus or minus 3°F. As already seen, cold and hot temperatures are measured in each primary loop and the signals fed separately into auctioneering units, where the largest impulse is selected. The information yielded by the auctioneering units is combined in an averaging unit which elaborates the primary coolant mean temperature. This is compared with the reference temperature in a subtracting unit which gives a temperature error signal. This signal is combined in a summing unit with a stabilizing indication proportional to the rate of neutron flux change. The resulting signal is used to drive the reactor control rod mechanisms.

The use of auctioneering units provides good reliability: if one of the temperature detectors gives a faulty indication lower than the others, for instance, it is eliminated by the auctioneering unit. On the other hand, if the faulty signal is too high, it is accordingly selected, and this gives an average temperature which is too high. The resulting correction will be an insertion of the control rods, which is of course unnecessary, but which does not impair the safety of the reactor.

Station in six parts

The station is divided into the following areas or buildings:

a. The *containment shell* has to prevent the escape into the atmosphere of radioactive vapours in the unlikely event of a major rupture in the primary loops. It encloses not only the four coolant loops, but also the equipment of the auxiliary systems which contain high pressure water. It is cylindrical, with a diameter of 70 ft and a total height of 138 ft. When the reactor is operating, the access opening is hermetically closed and no personnel may enter the container. The layout of the plant container is indicated on figure 8.

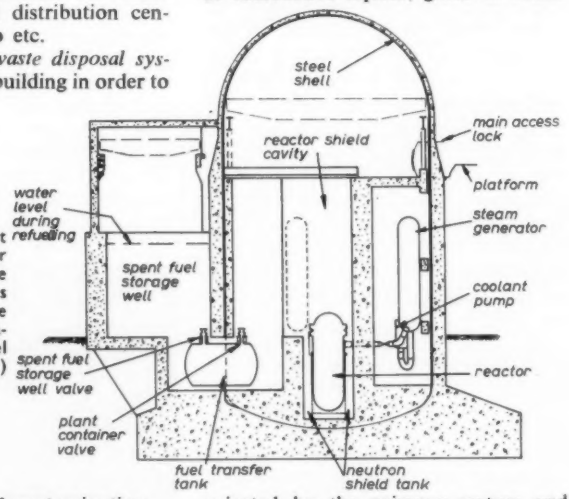
b. Against the vapour container, and on the same concrete foundation, is the building protecting the *spent fuel storage well*.

c. The turbogenerator group and its auxiliaries are located in a *hall* adjacent to the containment shell, in order to shorten the steam piping. Normal access is permitted in this building during operation.

d. *Reactor auxiliary systems building* encloses all the low pressure installations, together with several other facilities: decontamination room, health physics, sampling and electronic laboratories, sanitary installations, laundry etc.

e. The *plant auxiliary building* contains the control room, the cable room, the electrical distribution centres, the repair shop etc.

f. The *radioactive waste disposal system* is in a separate building in order to prevent spreading of contamination.



The steel containment shell encloses the four coolant loops and the auxiliary systems equipment. On the same concrete foundation is the spent fuel storage well (Fig 8)

The biological shielding is divided into four parts (figure 8):

1. The neutron shield tank completely encloses the reactor vessel and supports it; filled with water, its purpose is to absorb the neutrons leaking through the vessel wall

2. The primary shielding is a reinforced concrete structure enveloping the neutron shield tank and designed to attenuate radiation from the reactor to the same level as that from the primary coolant loops; the upper portion of the shield extends up to form the reactor cavity

3. Secondary shielding surrounds the vapour container and reduces reactor plant radiation to one-tenth tolerance level

4. Auxiliary shields are provided around several parts of the station, such as spent fuel storage well, purification demineralizers, and waste storage tanks.

Equipment malfunctions are reported in the control room by visible and audible alarms and are detected by several types of instruments:

a. Airborne particle detectors are located in the containment shell and at the stack exhaust

b. Boiler leak detectors are capable of indicating minute leaks in the boiler tubes, by the slight contamination of the secondary steam

c. Gamma detectors are used throughout the plant to detect leaks, excess contamination, radioactive deposits, area radiation level etc

d. Neutron detectors are used to monitor the efficiency of the reactor shield tank, and to check neutron flux in the spent fuel well to avoid the approach of a critical mass.

Active waste disposal system

This system, sketched in figure 9, is designed to handle the total quantity of radioactive liquids, gases or solids rejected by the primary system and the service buildings.

The liquid wastes, irrespective of their activity level, are divided into two categories:

1. the primary system effluents containing dissolved hydrogen and fission product gases

2. liquids containing dissolved air.

These radioactive liquids flow in the contaminated drains collecting tank, from where they are pumped batchwise

to the waste hold-up tanks. As soon as enough volume has accumulated in one of these tanks, or after a sufficient decay period, processing is started by the gas stripper, where the liquids get rid of all fission and inert gases by a countercurrent flow of steam.

Stripped liquids are charged to an electrode-type evaporator for concentration of the activity. The steam produced passes through a glass wool packed, deep bed filter to reduce carry-over of entrained aerosols. The condensed liquids are cooled and sent to a control tank, where they are sampled and monitored. In this way, the water can be purified to a sufficient extent, eventually by recycling, to permit its re-use as make-up water for the primary system. This method reduces the total amount of radioactive materials disposed of by water dispersion in rivers. The evaporator bottoms are mixed with cement and solidified in steel drums which, after 60 days decay, are shipped away without additional shielding for ultimate disposal, either in land or at sea.

Storage of liquids, gases, solids

The waste liquids from the laundry, the decontamination rooms, or the contaminated areas, are collected in a separate tank for sampling and analysis. If their activity level is sufficiently low, they are mixed at a controlled rate in the condenser discharge line. If not, they are transferred to the waste storage tanks and treated as reactor effluents.

Gaseous wastes are divided into hydrogen, radioactive gases and air. They are collected from the stripper and from the vapour space of all the reactor effluent liquid drain and hold-up tanks by a completely closed header system. After going through a catalytic re-combiner, the gases are stored under pressure for a 53-days decay period. They are passed through a deep bed particulate filter and then released at a carefully controlled rate for mixing with the ventilation air flowing to the stack.

Combustible solid wastes, such as removable floor covering, contaminated clothes and papers, are carried to the waste disposal building in fibre drums, and burnt in an airtight incinerator. The flue gases are cooled and passed through a wet gas scrubber to remove all the particulate material. After further filtering and careful control, they are sent to the stack. Ashes from the incinerator are sprayed with water in steel drums, solidified with cement and shipped away.

Non-combustible solid wastes consist of filter cartridges and various items of contaminated equipment. They are immobilized and shielded in concrete for final disposal by burial.

Refuelling of the reactor will be necessary at the end of the core life, that is after a minimum of 10,000 hours of full power operation.

Underwater fuel handling has been selected for several reasons:

1. water provides adequate cooling of the spent fuel elements
2. water gives sufficient radiation shielding, but still permits the usual observation of the operations to be performed
3. if sufficiently purified, water used for shielding purposes can be mixed with the primary coolant
4. underwater manipulations eliminate all danger of fire during refuelling.

Fuel handled under water

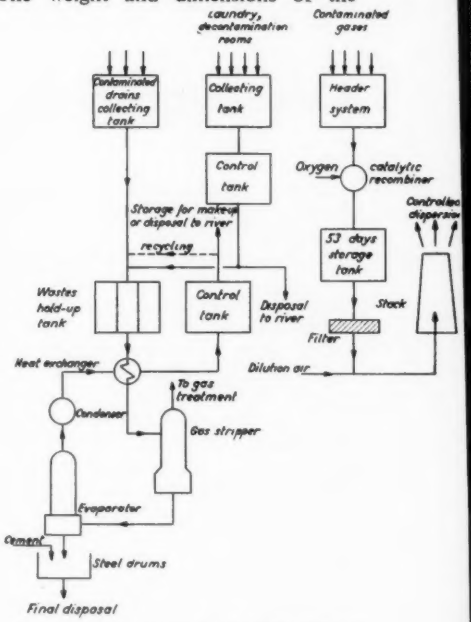
Refuelling being rather infrequent, it can be combined with the necessary periods of plant general overhaul. Power production is stopped by inserting the control rods, and borated water is injected for cooling down. The containment shell access is opened and the pressure vessel head bolts are removed while the reactor pit is dry (figure 8). The cavity is then filled with borated water, the head is removed by the crane and stored underwater. The control rods being previously disconnected, they remain inserted in the core.

Once the reactor internals are removed, it becomes possible to lift the fuel assemblies one by one out of the core, and to carry them underwater in the canal leading to the fuel transfer tank. Each fuel assembly is lowered in the tank through an access valve and transferred outside the plant container. There it is lifted out of the tank and placed in a rack located underwater in the fuel storage well. After a sufficient decay period, the spent fuel assemblies are inserted into lead-shielded containers which are shipped to the reprocessing plant.

Reliability proved in Shippingport

The inherent stability of the reactor has been demonstrated by operating the Shippingport power station. On December 28, 1957, the power fell down from 68,000 kW to zero because accidental interruption of steam flow. Scramming of the reactor was not necessary. The temperature went up several degrees F and the pressurizer absorbed the water surge, without opening of the relief valves. The rods were lowered at normal speed to re-establish previous temperature and pressure conditions. Several other incidents of the same type have proved the reliability of the system.

The only piece of equipment which is exposed to radiation damage is the pressure vessel. However, the thermal shield considerably reduces the radiation level, and the high temperature of the coolant provides a continuous annealing. Unlike solid moderators, water does not suffer from radiation damage. The only noticeable effect comes from radiolytic decomposition, which is immediately compensated by oxygen - hydrogen re-combination. There is no chemical affinity between the materials present in large quantities in the primary system: water, stainless steel, uranium oxide. This is true for temperatures up to 3500°F. The weight and dimensions of the pressure vessel permit its fabrication in the shop, where it is made with extreme care and numerous controls.



All the liquid, gaseous, and solid radioactive wastes from the primary circuits and service buildings are handled by this disposal system (Fig 9)

This list of safety features could be extended further. But let us suppose that, despite all the protection devices, an accident occurs, resulting in a major breakthrough in the primary piping. The fuel elements are exposed without water, and after 5 to 10 minutes some fuel claddings may reach the melting point, due to sensible and decay heat. There is ample time to put in operation the safety injection system which supplies borated water to be pumped into the core. Each loop is provided with an injection line, so that borated water can be charged, whatever place the rupture may be located. The charging pumps have electric motors and are duplicated by other ones driven by petrol engines.

In the immediate future the best bet is metallic fuels, in 5-10 years uranium dioxide in metallic cans, and in the more distant future, graphite cladding. This is the conclusion of the first international symposium on fuel elements, held recently in New York and reported here by the only British delegate

G. B. GREENOUGH, MA, PhD
Deputy Head of Laboratories,
Windscale Works, UKAEA

Fuel elements today and tomorrow

—some current developments

IN THE PRODUCTION of nuclear power, none of the problems has such a vast range of possible solutions as the best way in which to present the nuclear fuel to the neutron flux and to the coolant. Yet this remains the problem to which there are fewest clear answers, particularly in the quest for economic nuclear power from land-based stations. It was therefore welcome to attend a symposium which was confined to fuel elements where all aspects, from fundamental irradiation damage to the details of metal working processes, were discussed (liquid-fuelled systems were excluded). The symposium held in New York on January 28 and 29 was jointly organized by Columbia University and the Sylvania-Corning Nuclear Corporation. While many of the 450 delegates at the Conference came from the USA, where there are a large number of firms interested in the manufacture of fuel elements, there were representatives of 17 different countries.

Emphasis on economics

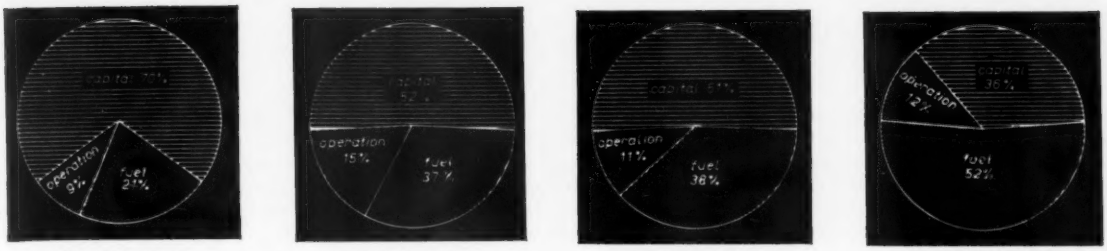
It was clear from the number of references made to the economics of nuclear power that this feature is uppermost in people's minds. Particularly in the USA, where capital charges are higher and the cost of power using conventional fuels is lower than in Europe, it seems quite clear that nuclear power is not likely to be economic for at least a further ten years. However, in Europe and in other countries with high conventional fuel costs, economic production of nuclear power could well be attained by the mid-1960s. R. B. Gordon of the Atomics International Division of North American Aviation Inc, showed a diagram (figure 1) giving a rough estimate of the breakdown of power cost for four different reactor systems, using American costs. In each case the cost of the nuclear fuel cycle is high and it was to this that the symposium essentially directed its attention. It was also clear that the present economic evaluation is very susceptible to military demand and supply, which influences markedly the cost of enriched U-235 and also the value of plutonium obtained by irradiating uranium containing quantities of U-238.

In his technical introduction, S. B. Roboff, also of Sylvania-Corning classified fuel elements into types depending on the prime purpose of the reactor in which they were employed. In plutonium-producing reactors, in both the US and the UK, the fuel is natural uranium canned in aluminium or magnesium. Generally the fuel is in its most concentrated form with a small surface to volume ratio, largely for nuclear reasons. Materials testing reactors, and some reactors used for training purposes, largely use enriched uranium in the form of an aluminium-uranium compound where the uranium is dispersed as UAl_3 in the matrix of aluminium, this fuel being clad in aluminium, the whole bonded together by hot rolling. These plates are assembled into fuel elements by brazing them to form either an element in the form of a square box or one with concentric fuel-laden plates. While most of this type of element are used in heavy water-moderated and heavy water-cooled reactors, it is interesting to note that they are also employed in the Brookhaven reactor which is graphite-moderated and air-cooled. In package power reactors, where a small size for a high power is the most important criterion and the economics are not very relevant, the elements are similar in principle to those used in testing reactors.

In reactors intended for electrical power production for normal commercial use, the economics of the reactor are the overriding consideration. In the UK the first round of reactors will be fuelled with natural uranium metal canned in magnox. However, it is clear that in the US such systems are far from economic, mainly because of the higher capital charges which apply, and very many different types of fuels and systems are being examined. It was Mr Roboff's view that reactors depending on liquid fuels were not likely for many years because of probable difficulties due to corrosion and the expense of shielding and maintenance of the circuits outside the reactor.

Best use of natural resources

Most reactors at present planned depend on the production of energy by burning U-235 which is a very rare isotope in naturally-occurring uranium. R. Foote of the Argonne



225 MWe GCR **150 MWe PWR** **100 MWe SGR** **150 MWe OMR**

Percentage cost of the fuel cycle varies widely with reactor type (Gordon) (Fig 1)

National Laboratory argued that as well as considering the economics of reactor operation, some thought should be given to the best utilization of the available energy in the natural resources. To do this ways must be found of burning Pu in reactors, produced by neutron irradiation of U-238, or alternatively of irradiating thorium to produce U-233 which could then be used as a fuel. He summarized the scientific data on the irradiation damage effects that occur in metallic uranium, the two most important ones being the irradiation growth, best defined as a change of shape but no change of volume, and the swelling which occurs at high temperatures — the change in volume rather than a change of shape. In his view the most likely metallic fuel is uranium so alloyed that it remains in the gamma phase. This would have to be enriched and for an economic cycle, Dr Foote thought that it would have to be by plutonium.

Use of thorium cycle

M. C. Woolsey of Atomics International and R. E. Tate of the Los Alamos Scientific Laboratory were both concerned with the development of fuel elements which could be used in cycles designed to utilize natural resources to a maximum. Dr Woolsey dealt with fuel elements based on thorium; these will have the advantage that irradiation damage is likely to be less than in uranium because of the simpler crystal structure of thorium. He quoted the results of one experiment in which Th/10%U had been irradiated to 1·2% burnup with a central metal temperature of 675°C and a surface temperature of 500°C, the volume increase due to the release of fission product gases being only 4%. A whole series of elements of the type shown in figure 2 have now been made for use in the sodium reactor experiment where the finished uranium content is 7·6% of highly-enriched material in thorium. The enrichment of U-235 will be replaced by U-233 during the fuel cycle although the conversion of thorium to U-233 is not quite good enough to avoid the necessity of occasional additions of U-235 during the cycle. Dr Woolsey also thought that it might well be that casting these fuel slugs, instead of extruding as at present, will prove to be a more economical method when U-233 is present because the alpha activity of the latter makes remote handling methods essential. Unfortunately, the economics of this cycle do not appear to be very promising at the moment although he thought that this would not be so if it were not for the military aspects of the more normal fuel element cycles.

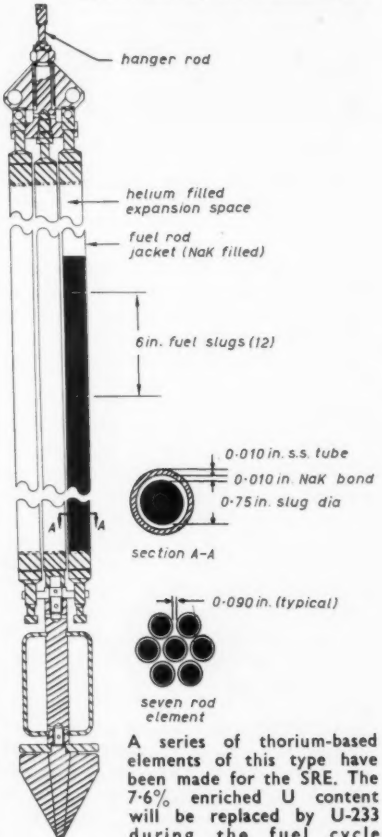
There are two possible methods of using plutonium as a reactor fuel: small amounts can be used to enrich all fuel elements, or a few more highly enriched elements could be distributed through the reactor — known as 'spiking.' Reviewing work on the subject, R. E. Tate said that metallic solid plutonium is clearly of no use because of the multiplicity of phase changes and low melting point. Most experiments that have been carried out to date have been based on the use of an aluminium/plutonium alloy clad in aluminium, an element similar to that normally used in testing reactors. However, attempts will be made soon to get higher fuel temperatures. For instance, at Los Alamos an experiment is proposed to irradiate molten plutonium in tantalum cans as a possible method of using plutonium fuels at temperatures of about 680°C; in simple form this is a capsule 8·5 in. long, 0·375 in. dia, ¾ filled with Pu.

Uranium dioxide strongly favoured

It was clear from the general discussions and from the particular interest shown in certain papers that uranium dioxide is felt to be the likely fuel for reactors showing reasonable thermal efficiencies and economies of operation comparable with those using familiar fuels. O. J. C. Runnals, Atomic Energy of Canada Ltd, described the basic irradiation characteristics of UO_2. Its outstanding merits are that its irradiation stability is exceptionally good, particularly that of the stoichiometric material. Figure 3 shows the appearance of two different compositions after identical irradiations.

Its compatibility with probable coolants is also good. This is important because it means that a can failure does not give rise to a catastrophic chemical reaction. In particular, reaction of UO_2 with CO_2 is very small, with steam there is a little reaction to give $UO_{2.25}$ and with liquid sodium at 600°C reactions are negligible. The reaction of UO_2 with possible canning materials — beryllium, zirconium and stainless steel—is also small. The one unsatisfactory property of uranium dioxide is that its thermal conductivity is low and that it decreases with increasing temperature; figure 4 shows a specimen in which the central zone had been molten during irradiation, despite the high melting point of 2750°C. L. W. Kates of Sylvania-Corning also showed data (figure 5) which demonstrated that the amount of fission product gas released is dependent on the initial density of the sintered oxide; if the densities are less than 92%, when the voids are likely to be interconnected, the amount of gas released is increased by a factor of nearly 10.

The economics of the manufacture



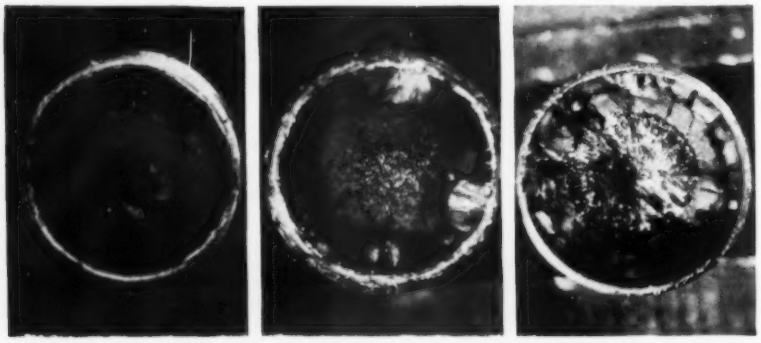
A series of thorium-based elements of this type have been made for the SRE. The 7·6% enriched U content will be replaced by U-233 during the fuel cycle (Woolsey) (Fig 2)

of UO_2 elements was touched on by Dr Runnals, Mr Kates and Dr Gordon, and in rather more detail by Dr R. Caillat of the Commissariat à l'Energie Atomique, in which he described the detailed operation of a plant producing 2 tonnes per month. In the French process the starting material is UO_3 which is reduced to UO_2. The surface area of the UO_2 governs the temperatures necessary to give a final sintered product of high density, lowest sintering temperatures being necessary when the UO_2 surface area is about 12 m^2/g. The sintering is done at about 1600°C in a controlled atmosphere of cracked ammonia.

Stainless cladding most popular

Although the UK is developing beryllium as a canning material for UO_2, the material most favoured elsewhere for large-scale use is stainless steel because of the easier technology. There is a stiff absorption penalty to pay and a great encouragement for thin cans. Dr Runnals hopes to develop at Chalk River fuel elements in stainless steel cans where the wall thickness is as little as 0·006 in. Both Dr Runnals and Mr Kates have had a little experience of swaging stainless steel cans on to UO_2 but in neither case was it very successful because of a tendency for the stainless steel to crack from the inside. At the Sylvania-Corning Nuclear Corporation isostatic pressing at around 1200°C and 13–14,000 psi is being tried as an alternative to sintering.

A type of element which is very popular in the United States, developed initially for use in materials testing reactors but which can be improved for use in power producing reactors, is that in which the enriched uranium is dispersed in a metallic matrix and the whole clad in aluminium or stainless steel sheets. J. Cunningham of the Oak Ridge National Laboratory described the development of such plate type elements. He pointed out that this type of fuel element is always likely to require high enrichment and is likely only to be acceptable in reactors where compactness is of prime importance. The feature which it is most difficult to attain metallurgically is the metallic bond necessary between the enriched matrix and the cladding material for high power ratings. One method of attaining this, as in the standard method of making aluminium clad MTR elements, is to hot roll the sandwich of matrix and cladding. A more effective method, described by Dr Schumar of the Argonne, is to sprinkle silicon between the aluminium clad and the aluminium base fuel matrix. When such an inter layer is hot pressed the aluminium silicon eutectic is formed with a lower melting point than the other materials; this flows out of the junction, sweeping away the oxide, thus permitting very good intermetallic contact between the cladding and matrix.



Cross-sections of zircaloy-2 clad uranium dioxide specimens looked like this after irradiation at Chalk River (Runnals). Left and centre were 0·41 in. dia and had 4500 MWd/t; their composition was, respectively, $UO_{2\cdot00}$ and $UO_{2\cdot15}$ (Fig 3). The central zone of the rod at the right (Fig 4) melted under irradiation giving a heat flux of 700 W/cm length for 60 sec

The most popular development of the original aluminium base elements for higher powers and temperatures is one in which the enriched matrix consists of UO_2 in stainless steel, clad in stainless steel. After 2% burnup at 500°C there were no dimensional changes at all. After 50% burnup the matrix metal was a great deal harder than initially but no cracking occurred; porosity was visible in the UO_2.

Fuel elements, basically very similar to the plates described by Dr Cunningham, can be produced as tubes by large-scale production techniques. This was shown by W. Maxwell of the General Nuclear Engineering Corp. Tubular fuel elements are advantageous in some ways from the reactor point of view: in particular more efficient cooling might be possible. From the fabrication point of view they would be preferred if they could be made by co-extrusion methods. Work is being pursued in this field with a view to developing elements suitable for pressurized water reactors. It seems likely that by loading the extrusion press with pellets of the appropriate shape, the conditions could be controlled sufficiently to produce tubular fuel elements where the core and cladding are of the correct dimensions.

High temperature operation

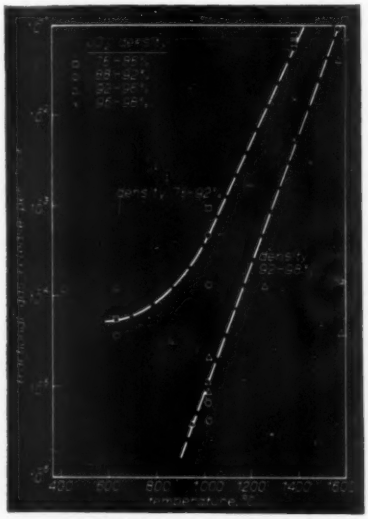
Fuel elements which might be used at very high temperatures were reviewed by A. Strasser of the Nuclear Development Corporation of America. Arbitrarily he took 'high temperatures' to cover fuel elements used in reactors where the coolant exit temperature is 800°C or greater. Such reactors are extremely attractive for power production because of their great thermal efficiency: in addition to systems using normal steam cycles the coolant exit temperature is high enough to make a closed cycle gas turbine feasible. Studies have also been made of high temperature reactors for the propulsion of aircraft and rockets and finally for possible use in chemical plants where the nuclear irradiation as well as the high temperature may assist the chemical reaction.

It is quite clear that the whole field is still in its very early days: ideas are nebulous, and a great deal of research effort is still required to make any impression on the very large technological problems that exist. Of the 39 different possible fuels mentioned, there are only three, UO_2, UC and U_3Si, about which much data exists. The main advantage of UC over UO_2 is that it has a higher thermal conductivity and that it does not decrease with increasing temperature. Mr Kates also reported some promising new information on the irradiation behaviour: after 2000 MWd/t at 770°C, only 0·1% of the gaseous fission products had been released. But the summary of properties given in Dr Caillat's paper brought out its bad properties: its reactivity with CO_2 and with steam are so large that its use as a reactor fuel in reactors cooled by these materials may well be precluded.

For canning materials the broad choice is between a metal, which has the advantage that it can be made leak proof easily but for which the compatibility problems are serious, and a ceramic material which has very good compatibility in many fuels and coolants but which will be very diffi-

cult to seal and, because of the low thermal conductivity, is likely to have a poor thermal shock resistance.

The current type of metal canned uranium oxide fuel element hardly comes into the field of high temperature fuel elements, and the high temperature element that has received most study is one in which uranium in the form of oxide or carbide has been canned in graphite. The fuel may be in the form of a discrete lump in the middle of the graphite or may be finely dispersed throughout the porous graphite. In either case an 'impervious' coat is required for the graphite and the development of such



Amount of fission product gas released in uranium dioxide under irradiation depends on the initial density of the sintered oxide (Kates) (Fig 5)

a coating which is stable under irradiation is the outstanding difficulty of systems based on the uranium/graphite fuel elements. Table 1, presented by L. W. Kates, shows some of the first available irradiation data on these new types of fuels, although these particular spheres have no impervious coating. A little work has also been done on elements in which the impervious cladding is by SiC, or Al_2O_3 or a cermet of Al_2O_3 and chromium.

German 'potato heap' reactor

Dr Metz read a paper prepared by Dr Boettcher of Degussa in Germany which enlarged on one particular example of the high temperature fuel element based on uranium and graphite. It is hoped that the first German design prototype power reactor will use this fuel element. The graphite fuel elements will be in the form of spheres 2·3 in. diameter and these will be piled up in the reactor; in fact the design is colloquially known as the 'potato heap' reactor. The balls are made hollow, filled with UO_2 and the opening closed by a screwed plug, the thread of which must be reimpregnated to form a seal. On heating the UO_2 is converted to carbide, which is then stable with respect to the graphite. Dr Boettcher points out that many of the fission products will be retained in the balls as carbides but some will escape. Methods will have to be devised for dealing with these.

Because of the interest in graphite for high temperature reactors, Dr Green has studied the mechanical properties of graphite at temperatures of about 2500°C. He has shown that the short term strength is good but that the creep strength is a source of possible worry. Graphite of density 1·73 g/cc gives the best properties, but this density can only be attained when no more than 0·12 g/cc of uranium is dispersed in the graphite.

In a brief review of fuel element development in France, B. de Lasteyrie from Cie pour L'Etude et la Réalisation de Combustibles Atomiques described the process at present in use in making the fuel elements for the new French reactor EL3. This reactor is for the high flux of 10^{14}. The fuel elements are made from an alloy of enriched uranium with 1·5% molybdenum. The tubular elements are made by casting and heat treatment from the beta phase in a way which is basically similar to those which have been employed in the UK for making Calder Hall fuel elements.

A brief review of the fuel element programme of the UKAEA was presented by the author in place of Dr Hardy who was unable to be present at the Conference. Fuel elements which will be used in the first CEGB reactors, designed primarily to produce electric power, are improved versions of the Calder Hall fuel elements. At the present time the absolute maximum fuel temperature is taken to be that of the alpha/beta phase transition temperature of 660°C. The fuel shape chosen for nuclear reasons is by no means the best for heat transfer and one of the major improvements in the fuel elements for the power stations has been in the heat transfer details. In particular, under similar conditions of gas flow, the power station elements have better heat transfer characteristics and are, moreover, designed so that the effect of small manufacturing variations about the theoretical, e.g. in fin profile, have smaller effects. Thus the range of fuel temperature about the mean will be less and the mean may be taken closer to the maximum. Finally the civil fuel elements are better than the Calder element because they permit greater fuel deformation before the heat transfer characteristics are greatly influenced. In the United Kingdom the output of fuel elements will be about 1100 tonnes/year by the mid-1960's.

Corrosion and mass transfer

The results of examination of irradiated Calder elements are 22 failures in the 50,000 elements loaded. These failures can be split into two types: those arising because of rare manufacturing defects escaping the inspection procedure and those arising because of small grain boundary cracks in the magnox cans produced by small amounts of irradiation growths in the fuel. The dimensional stability of the fuel is generally exceptionally good, both with regard to length changes and to changes in density.

One of the major problems in reactor systems where the coolant is a liquid, either sodium or water, and in systems using steam, is due to corrosion and mass transfer. J. E. Draley of the Argonne summarized some of the more important problems in this field. In general it appears that irradiation does not enhance these effects to a large degree; those differences that are noted in the reactor are due to the creation of active species in the corroding medium rather than to irradiation effects in the solids. Zirconium alloys are notably resistant to aqueous corrosion in pile and this is the reason for the current interest in this material displayed in the United States. In gas-cooled reactors dry corrosion is the factor to consider;

TABLE 1—Recent irradiation data on fuelled graphite spheres (*Sanderson and Porter*)

	IMPREGNATED (SYLCOR)	ADMIXTURE (NAT'L. CARBON)
fuel particle size, microns	~1	~100
irradiation temp, °F	1200	1200
U-235 burnup, %	1–1/2	1–1/2
fissions/cc of matrix	$5{\cdot}8 \times 10^{18}$	$5{\cdot}8 \times 10^{18}$
volume shrinkage, %	1	1/4
surface hardness	increased	increased
compressive strength	increased	increased
impact strength	not impaired	not impaired

NOTE: *After tumbling abrasion tests, both types showed no spalling, cracking or peeling of the surface.*

again irradiation may have some effect, e.g. it is known that air has a greater effect on aluminium in pile due to production of active NO species.

The scientist is rather apt to consider fuel elements as items designed solely to take account of the effects of irradiation and temperature. However, throughout the Conference many speakers noted that, for economic reasons, the fuel element should be designed not only from the irradiation point of view but so that it can be manufactured as cheaply as possible. J. F. Schumar of the Argonne dealt specifically with fabrication techniques. In fuel elements where the can is bonded to the fuel he was clear that manufacture by hot rolling or by extrusion of the clad element was the best approach. He pointed out, however, that to do this the working properties of the fuel and the clad must be similar. As particular examples he quoted the successful roll cladding of uranium containing 1½% Nb and 5% Zr with zirconium alloy and the successful extrusion cladding of a uranium alloy containing 2% zirconium clad in zircaloy 2.

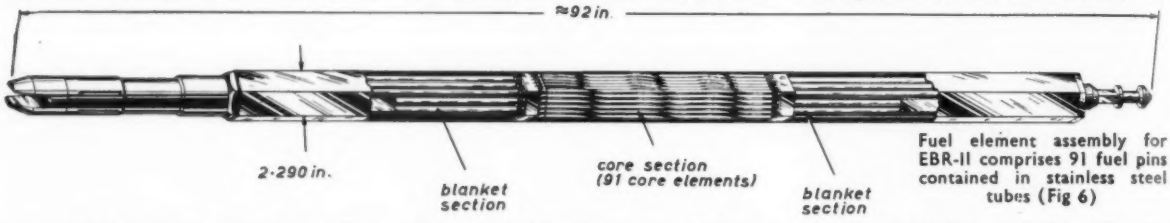
Both Mr Schumar and Dr Gordon pointed out that the use of wet chemical methods for fuel processing added appreciably to the fuel cycle costs. A possible alternative is to use pyrometallurgical methods. Such methods however, will never remove all the fission products, only those with high vapour pressures or forming slags. The remaining 'fissium' alloy, with some fresh added fuel, must be reprocessed to fuel elements by remote handling methods.

The Experimental Breeder Reactor II is designed to test such a fuel processing cycle and the fuel, after several irradiation/processing cycles, will be about 70% U, 20% Pu, 10% fission products — principally molybdenum, ruthenium and technetium. This is cast into pins using precision bore glass tubes as moulds. These are put into stainless steel tubes, with sodium as a heat transfer medium, to form the fuel element, 18 in. long and 0·174 in. diameter. Figure 6 shows the completed element, containing 91 of the fuel elements and a breeder section at each side.

Swelling—the limiting factor

On fuel element behaviour under irradiation, Mr. Kates thought the ultimate limiting feature would be the release of fission product gases causing swelling. In uranium metal this swelling would start at temperatures between 400 and 500°C, but in uranium dioxide the dimensional changes are small unless some part of the oxide melts. In the can the two major worries are a decrease in ductility during irradiation and corrosion effects. The bond between the fuel and the can could limit irradiation life in a variety of ways. In those elements depending on a diffusion bond, e.g. nickel between uranium and aluminium, the irradiation may well enhance diffusion effects. In elements in which the bond between fuel and can is a gas, then an increase in the gap between the two could cause quite large increases in temperature in the fuel. The actual release of fission product gas from fuels could cause such increases in can/fuel gap and this has been a source of possible worry in UO_2 fuel elements. But data so far available, shown in table 2, indicates that this will only happen if the UO_2 melts. However, examples quoted by Mr Kates showed that recorded fuel element failures were often due to other causes.

Study of the economics of fuel element cycles, even at the present time, is particularly valuable since it serves to show the lines in which research and development effort could be most fruitfully deployed. For instance, Dr Gordon discussed the economics of UO_2 as a fuel and showed that if the preferred cycle was of a fairly low burnup then it was better to use stainless steel for canning, but if high burnups were anticipated then zirconium would be a better canning material. On the fabrication side he emphasized that the cost of inspection during and after manufacture could be quite high, and he was much in favour of avoiding welding processes because of the high inspection cost they involved.



Fuel element assembly for EBR-II comprises 91 fuel pins contained in stainless steel tubes (Fig 6)

Arbitrary choice must be made

The Conference as a whole gave delegates the impression that there was a vast range of possible combinations of fuel and can for reactor use but the amount of irradiation data was completely inadequate to enable a sensible choice to be made. It is clear that all the research effort so far expended has done no more than scratch the surface. Therefore if it is necessary to develop atomic energy on a commercial scale in the next few years, and this is the case in many countries even if not in the United States, then some fairly arbitrary choice of suitable fuel element must be made and the available scientific effort concentrated on this particular choice. This places a great premium on the technical judgment of a few senior scientists and on their strength of mind to persevere with the chosen paths despite superficial attractions of the many possible alternatives. The general impression left by the colloquium is that in the immediate future the best elements are likely to be based on metallic fuels in metal cans, in 5–10 years on ceramic fuels, probably uranium dioxide, in metal cans and in the more distant future on a fuel based on graphite cladding.

TABLE II—Data on high burnup zircaloy-2 clad UO_2 fuel elements

BURNUP, MWd/t	CALCULATED CENTRAL TEMP, °C	DIMENSIONAL CHANGES DIA, IN.	DIMENSIONAL CHANGES LENGTH, IN.	MOLTEN ZONE, DIA, IN.	FISSION GAS RELEASE, % Kr–85
14,000	2400	0	0	not melted	
22,000	2750	+0·012	0	0·200	
25,000	2750	+0·015	0	0·230	
12,000	2200	0	0	not melted	
6,430	1400	0	0	not melted	0·25
12,400	2750	+0·009	+0·009	0·250	13·6
12,100	2750	+0·008	+0·015	0·275	15·3
6,100	2200	0	0	not melted	
6,700	2400	0	0	not melted	
14,400	2750	+0·002	0	0·290	
15,500	2750	+0·018	0	0·325	35·6
7,930	2400	0	0	not melted	1·2

This new series began in February with an article on the wide range of detectors available and their operating principles. This one covers the efficiency of the instruments for different types of radiation, and these results will be applied in a further instalment to show for which applications each detector is best suited

by W. R. LOOSEMORE, B.Sc., A.R.C.S.
A.E.R.E., Harwell

RADIATION DETECTORS

2—their efficiency

GAS IONIZATION DETECTORS

In this section geiger and proportional counters will be considered, first as detectors of charged particles.

External source

When the radioactive source is in solid form, external to the detector, the measurement is usually carried out with an end-window geiger counter, and the overall efficiency can be expressed as

$$E = G\,\varepsilon\,f_w\,f_b\,f_s\,f_e$$

where

G = geometry factor
ε = intrinsic efficiency of the counter for the primary particle
f_w = correction for absorption in the window and in the space between source and window
f_b = correction due to back-scattering from the source backing material
f_s = correction due to self-absorption in the source
f_e = correction due to dead-time of the counter and associated electronic apparatus.

The geometry factor G is due to the fact that only those particles will enter the counter which are emitted within a definite solid angle, which will vary both with the distance of the plane of the source from the window and with position in the plane of the source. In the simplest case of a point source on the axis of the counter, and assuming the boundary of the sensitive volume to be defined by a sphere of radius R (see figure 1), then

$$G = \frac{1}{4\pi r^2}\int_0^{\alpha} 2\pi R^2 \sin\theta\, d\theta$$

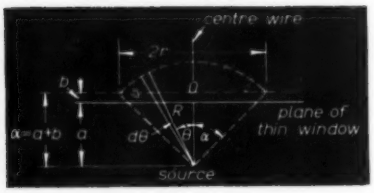
$$= \tfrac{1}{2}\,(1 - \cos\alpha)$$

$$= \frac{1}{2}\left[1 - \frac{d}{(d^2 + r^2)^{\frac{1}{2}}}\right]$$

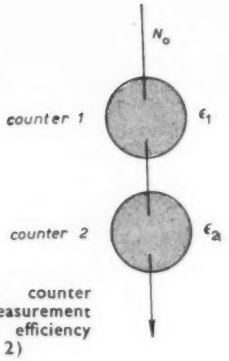
The distance d is uncertain since there is always a dead-space, 'a' in the figure, between the end window and the end of the centre wire, which is not measurable: a common value is 3–5 mm. When the source has a finite size the calculation becomes more elaborate and is subject to indeterminate errors due, for instance, to non-uniformity in the distribution of the activity. In order to minimize these effects the source diameter should not exceed half the window diameter and d should be less than 0·2 × window diameter.

ε is understood to mean the probability that a particle entering the sensitive volume of the counter will be detected. Let ϕ = probability that a single ion pair is produced by the primary particle in its path through the counter, S = number of primary ion pairs produced per cm at atmospheric pressure, p = pressure in the counter in cm Hg, and l = track length in cm. Then the number of ion pairs produced is $Slp/76$, and

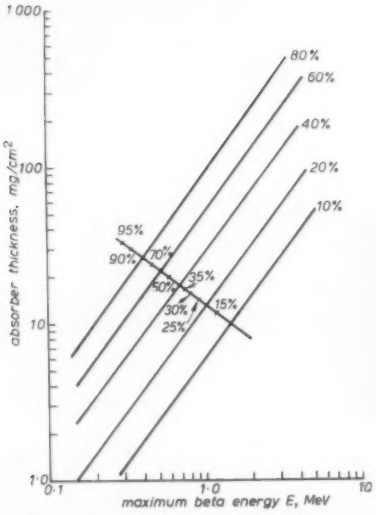
$$\varepsilon = 1 - \exp\left[\frac{-\phi Slp}{76}\right]$$



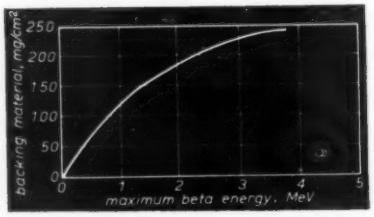
Schematic of end window counter for calculation of geometry factor (Fig 1)



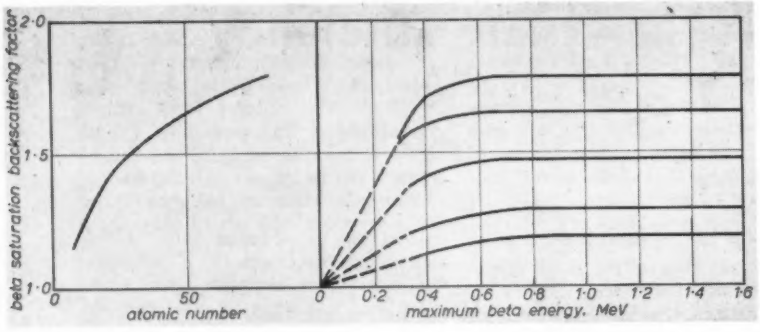
Coincidence counter array for measurement of counter efficiency (Fig 2)



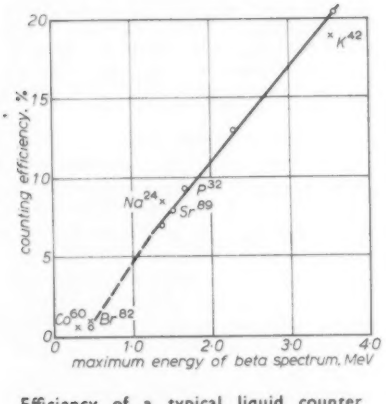
Absorption of beta particles in mica or aluminium (Fig 3)



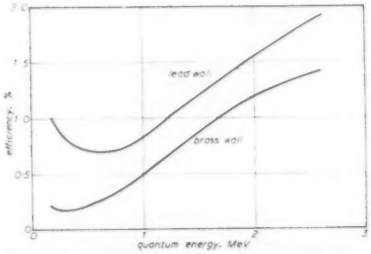
Thickness of backing material required to give saturation backscattering (Fig 4)



Saturation backscattering as a function of, left, atomic number (Fig 5) and right, maximum beta energy (Fig 6)



Efficiency of a typical liquid counter for 10 ml filling as a function of beta energy. Crosses are overall values for isotopes, circles values for beta particles (Fig 7)



Gamma efficiency of two GM counters with lead and brass walls as a function of quantum energy (Fig 8)

S is about 50 for fast beta particles, p commonly about 10 cm, l can be made not less than 1 cm using a limiting aperture, and in a well-designed counter $\phi = 1$, so that

$$\varepsilon \simeq 1 - e^{-6}$$

i.e. the intrinsic efficiency is at least 98%.

For alpha particles and protons the specific ionization is much greater, and the intrinsic efficiency is then 100%. Although the calculation is done in the context of an external source it does of course apply equally well for any arrangement of source and counter.

Experimental measurement

The intrinsic efficiency of a counter may be measured experimentally in several ways, one of which is illustrated in figure 2. Consider a beam of N_0 energetic charged particles traversing the upper counter per sec. If the efficiency of this counter is ε_1, the number detected per sec will be

$$N_1 = \varepsilon_1 N_0.$$

If the geometry factor for the upper to the lower tube is λ, then the number detected by the lower tube is

$$N_2 = \varepsilon_2 \lambda N_0,$$

and of this number N_2, a total of $\varepsilon_1 \varepsilon_2 \lambda N_0$ are detected in the upper tube. Thus the coincidence counting rate is given by

$$N_c = \varepsilon_1 \varepsilon_2 \lambda N_0,$$

and $$\frac{N_c}{N_2} = \varepsilon_1$$

which is thus measurable without knowledge of the geometry. The method is applicable to the energetic charged component of the cosmic radiation, but may be adapted to the case of a source emitting a beta and a gamma ray in coincidence, or two gammas in coincidence.

The window absorption for a known window thickness may be estimated from the experimental data in figure 3 for beta particles, but is best found by measuring the reduction in count rate produced by adding a series of absorbers of the same material and known thickness. The count rate is then plotted against absorber thickness and extrapolated to zero thickness, whence f_w can be computed. As a general guide it is found that an absorber thickness equal to 1/7 the maximum range attenuates a roughly collimated beam of beta particles by 50%. The range of alpha particles is so small that it is not normally possible to assay an external source of alphas using this type of detector.

The correction of backscattering, f_b, is necessary since beta particles emitted outside the acceptance solid angle may be scattered into the counter by the material of the source

holder. Thus the fraction of particles leaving the source towards the counter will be greater than that calculated from the solid angle. The fraction scattered will depend on the energy of the beta emitter, the thickness of backing material, and the atomic number of the scattering material. Figure 4 (*1*) shows the thickness of backing material necessary to achieve the saturation value of backscattering as a function of beta energy i.e. for a thickness greater than this value the backscattering factor is independent of backing thickness. The source backing is normally either thick enough to enable the saturation factor to be used or thin enough for the effect to be ignored. Figures 5 and 6 give the saturation backscattering factor as a function of atomic number and maximum beta energy for various backing materials. f_b may be measured by mounting the source on a very thin film of low atomic number e.g. nylon, and noting the change in count rate produced by placing backing material of increasing thickness immediately behind the source. The dependence of the backscattering factor on the beta energy of the source has been found to be due, at least in part, to the additional scattering due to the air and the window.

The self-absorption factor f_s arises due to the forward scattering by the material of the source tending to increase the fraction of particles counted and the absorption of radiation by the source tending to decrease it. Wherever possible the source should be thin enough for this factor to be neglected. If this is not possible the self-absorption may be measured by comparing the counting rate of a series of samples, each of which contains the same total activity but a different total weight of sample. The data is then normalized to $f_s = 1$ for zero weight of source when f_s is given for any weight of source.

f_e will be discussed separately in a future article.

Internal source

When the source is mounted internally in the counter most of the correction factors so far discussed may be reduced in importance. Thus the geometrical factor G will be 0·5 for a source holder without a defining rim, and the window absorption factor $f_w = 1$. The backscattering factor f_b may be eliminated by counting the particles emitted from both sides of the source (4π counting) which is mounted on a very thin film of low atomic number material (nylon or polythene), and the geometry factor G then is equal to 1. The counter filling gas is usually supplied pre-mixed from a high pressure cylinder and is flowed continuously through the counting volume.

Counting in liquids

If the activity to be detected is contained in a liquid the counter is often designed to have a thin wall, and the liquid is contained by a jacket surrounding the active length of the counter. A typical liquid counter has an active length of 6 cm, a wall thickness of about 40 mg/cm² and a liquid capacity of 10 ml; the efficiency with which it will detect beta activity in the liquid will be a function of the energy of the betas, since self-absorption will occur in the liquid. Figure 7 (*2*) gives some experimental data on a typical counter.

Detecting electromagnetic radiation

In using the gas ionization detector for electromagnetic radiation, the photon must transfer some or all of its energy to one or more secondary electrons which will then be detected if they enter the sensitive volume of the counter. For photon energies in excess of 100 keV the secondary electrons are produced primarily in the walls of the counter, and the contribution due to the gas may be neglected. The useful thickness of wall is limited to that corresponding to the range of the secondary electrons, and since gamma absorption coefficients are small the intrinsic efficiency of this type of detector is also low. The range of a beta particle in the wall material is not uniquely defined for any photon energy due to the varying energy acquired as the result of Compton scattering and to the possibility of multiple scattering, and hence an exact calculation of the efficiency is difficult. Let π, σ, τ = absorption coefficients per atom for the release of a secondary electron by photoelectric, Compton and pair production methods.

For photoelectric absorption π is proportional to

$$Z^5 \left(\frac{mc^2}{h\nu}\right)^{7/2}$$

and hence the detection efficiency for this method of absorption,

$\varepsilon_1 = k_1 N_0 \pi R_1$

where N_0 = no of atoms /cm³ of material

and R_1 = range of the photoelectron in the wall.

$R \propto (N_0 Z)^{-1}$, and hence

$\varepsilon_1 = k_1 \pi / Z$

$= Z^4 (h\nu)^{-7/2}$ for $h\nu < mc^2$.

For Compton scattering,

σ is proportional to Z,

and as before,

$$\varepsilon_2 = \frac{k_2 \sigma}{Z},$$

so that the efficiency of detection due to Compton scattering is independent of atomic number.

For pair production, τ is proportional to Z^2, and hence

$$\varepsilon_3 = \frac{k_3 \tau}{Z},$$

i.e. ε_3 is proportional to Z.

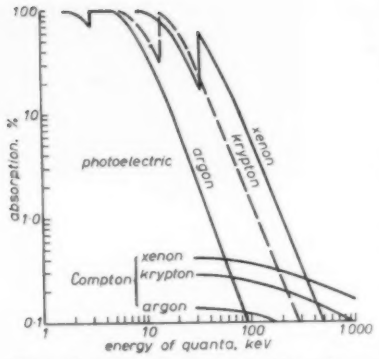
Thus for low photon energies the detection efficiency increases sharply with atomic number of the wall material so that, for instance, a GM counter with a tungsten wall has an intrinsic efficiency about 5 five times that of a carbon wall for the 0·4 MeV gamma from I-131. At very high energies (> 5 MeV) it again increases for increasing Z as the pair production process becomes important, but in the middle range, between about 0·5–5 MeV the variation in efficiency with wall material is not marked. Figure 8 (*3*) gives values of the total gamma efficiency as a function of photon energy in MeV, for two counters having walls of lead and brass.

Low energy X-rays

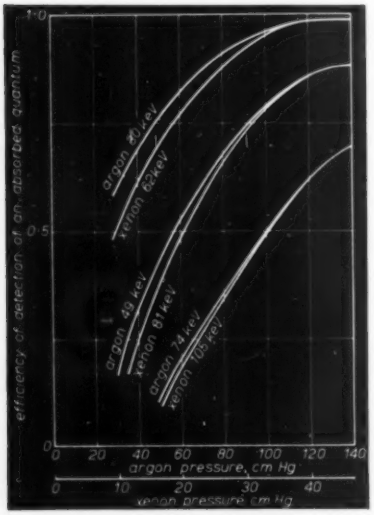
For the detection of low energy X-radiation, from 50–100 keV down to 3–5 keV, photoelectric absorption in the gas becomes the most important process. Figure 9 (*4*) shows the absorption in a depth of 5 cm of argon, krypton, xenon at NTP from which can be calculated the absorption for any given path length x of the radiation in the counter gas, since the fraction absorbed $F_A = \exp(-\rho C \pi / A)$ where ρ = gas density in gm/cm³, A = atomic weight, C = Avogadro's number. The rapid increase in photoelectric absorption with atomic number can be seen by comparing the curves for argon ($Z = 18$) and xenon ($Z = 54$).

To prevent attenuation of the radiation at very low energies a thin window of aluminium or beryllium may be used. Figure 10 gives data on the transmission of these materials, and it can be seen that a window of 0·5 mm Be gives a useable transmission down to 3·5 keV. The absorption coefficient of the gas will have discontinuities at photon energies corresponding to the binding energies of the K and L orbital shells and often the gas filling is selected for a particular measurement; the absorption edges are shown clearly in figure 9.

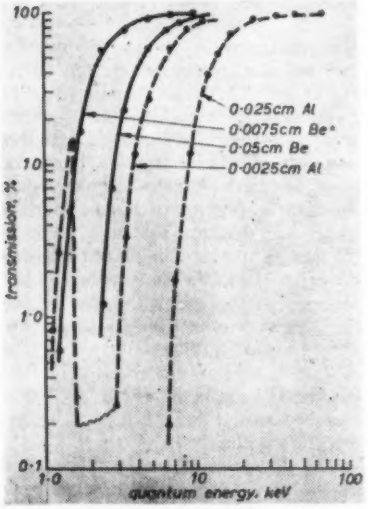
The detection efficiency represented by the total energy photoelectric peak will be reduced if fluorescent radiation characteristic of the gas, which may be emitted during the absorption



Photoelectric and Compton absorption in 5 cm of argon, krypton and xenon at NTP (Fig 9a)



Approximate efficiency of detection of an absorbed quantum in a 5 cm dia counter filled with argon or xenon (Fig 9b)



Transmission of X-rays through aluminium and beryllium as a function of quantum energy (Fig 10)

process, escapes from the counter. This will result in the appearance of a second peak in the energy spectrum at an energy equal to $E\gamma - E_f$, where E_f is the energy of the fluorescent radiation. The probability of this emission occurring depends on the fluorescent yield of each orbital shell, and the probability of its escaping will depend on the path length available for re-absorption. Some information on the fluorescent radiation from argon, krypton and xenon is given in table I.

DETECTION OF GAMMA RADIATION IN A MEAN-CURRENT ION CHAMBER

The saturation current to be expected from a gamma-sensitive mean-current ion chamber may be calculated from the expression

$$J = \frac{E_F \psi_a}{Wr}$$

where

J = ionization rate in ion/sec/g of gas

E_F = energy flux in eV/cm²/sec

ψ_a = mass energy absorption coefficient in cm²/g of wall

W = energy required to produce one ion pair in the gas, eV (usually about 30 eV)

r = ratio of the mass stopping powers of the wall and gas, which is here assumed to be unity.

$E_F\ \psi_a$ can be replaced by the doserate D in rads/sec at the detector due to the source if this is known, remembering that 1 rad ≡ an energy deposition of 100 ergs/g, and that 1 erg $= 6{\cdot}2 \times 10^{11}$ eV. Thus $E_F = 100D \times 6{\cdot}2 \times 10^{11}$ eV/cm²/sec, and $J \simeq 2{\cdot}1 \times 10^{12}D$ ions/sec/g $= 3{\cdot}35 \times 10^{-7}D$ amps/g.

Thus to increase the current produced for a given doserate it is necessary to increase the mass absorption coefficient of the wall and the mass of gas in the chamber. This latter can be accomplished by increasing the size of the chamber, and the density and pressure of the filling gas.

As an example, the TPA type ionization chamber has electrodes of aluminium, and an effective volume of 4·9 litres at NTP. When the filling gas is argon at a pressure of 20 atmospheres the current developed at a doserate of 0·36 rads/8 hours due to radium gamma rays is found experimentally to be 6×10^{-10} amps. The density of argon is 1·78 g/litre, and hence the calculated current to be expected from the chamber is

$$I = \frac{3{\cdot}35 \times 10^{-7} \times 0{\cdot}36 \times 1{\cdot}78 \times 4.9 \times 20}{8 \times 3600}$$
$$= 7{\cdot}2 \times 10^{-10} \text{ amp.}$$

GAS IONIZATION DETECTORS FOR NEUTRONS

Thermal neutrons are detected using the nuclear reactions

$_5B^{10}(n,\alpha)_3Li^7 + 2{\cdot}4$ MeV

or $U^{235}(n, \text{fission}) + 180$ MeV.

The B-10 may be present as BF_3 gas in a proportional counter, when the ionized track produced by a Li-7 or He-4 nucleus has a length of about 0·5 cm at NTP, or as a thin coating on one or both of the electrodes in a pulse or mean-current ion chamber containing, typically, argon or hydrogen as a filling gas. The reaction cross-section for natural boron containing 20% of B-10 is 750×10^{-24} cm²/atom, and is correspondingly increased when the material is enriched in B-10.

U-235 is deposited in a fission ion chamber as a thin oxide film of thickness 0·1–2 mg/cm² of natural uranium containing 1 part in 140 of U-235, or as enriched material. The fission cross-section of U-235 for thermal neutrons is 579×10^{-24} cm².

The efficiency of both types of pulse detector is usually stated as the count rate of the detector in unit flux of thermal neutrons.

If σ = reaction cross-section in cm²/atom, M = total coating weight in grams, C = Avogadro's number, A = atomic weight

then N = number of atoms able to react in detector sensitive volume

$$= \frac{MC}{A}$$

and the efficiency

$$E = \sigma N f_s \varepsilon$$

where ε = intrinsic efficiency of detector

f_s = self-absorption factor.

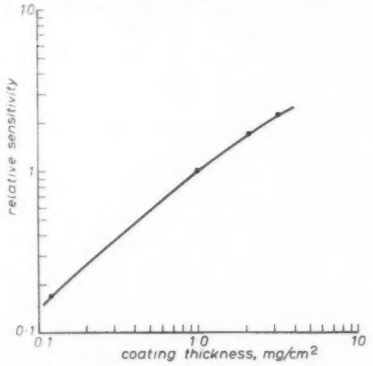
The alpha particle and Li-7 nucleus produced by the B-10 reaction, and the two fission fragments, will recoil in opposite directions and hence one of them will always produce ionization in the sensitive volume of the counter or chamber, so that the in-

TABLE 1 *Fluorescent radiation from argon, krypton, xenon*

GAS	X-RAY ENERGY (keV)			PROBABILITY FOR EMISSION OF PHOTOELECTRONS ON ABSORPTION	FLUORESCENCE YIELD OF K AND L SHELLS	
	K_α	K_β	L_β		W_K	W_L
argon	2·96		0·25	0·9	0·11	0·01
krypton	12·63		1·64	0·87	0·67	0·08
xenon	29·66	33·6	4·41	0·82	0·85	0·21

trinsic efficiency ϵ of these two neutron detectors will be unity.

The self-absorption correction f_s is necessary when the detector contains boron or uranium as a thin layer to account for the absorption of the very short range primary particles within the coating. The effect of self-absorption in a typical U-235 fission pulse ion chamber is shown in figure 11 (5) where the observed count rate increases less rapidly as the coating thickness is increased. The same general result is observed in boron-lined chambers.



Fission chamber sensitivity as a function of the coating thickness (Fig 11)

In BF_3 counters an additional correction has to be made to allow for the mass of gas contained in 'dead' spaces at either end of the counter but outside the active volume.

The efficiency (strictly the sensitivity) of a BF_3 counter will increase with gas pressure since N is directly proportional to p. A typical BF_3 counter has a diameter of 1 in., an active length of 6 in. and a filling pressure of 70 cm Hg enriched BF_3. The count rate of such a counter will be about 5 counts/sec/n/cm²/sec (6). The efficiency of a fission chamber will not depend on p provided that at the minimum pressure the quantity of charge released due to any ionizing event is above the threshold limit of the amplifier. A fission chamber containing 165 cm² of U-235 as a coating 1 mg/cm² thick will have a count rate of 0·12 counts/sec/n/cm²/sec.

A U-235 fission chamber may be used as a mean-current chamber in preference to one containing a boron coating, and has the advantage that for a given total coating absorption cross-section the current drawn for a given flux may be increased in the ratio 180/2·4, this being the ratio of the energy released during fission to that released by the B-10 (n, α) reaction.

SCINTILLATION DETECTORS

By a suitable choice of phosphor the scintillation type of detector may be used to detect the presence of all charged particles, photons and neutrons.

For the detection of alpha particles, having a range of a few cm air equivalent, a convenient phosphor is ZnS(Ag) quenched with Ni, since it is chemically stable in air and has the high specific light output of 500–700 photoelectrons per MeV energy absorbed, in conjunction with an efficiently coupled photomultiplier. It is available as a fine crystalline powder that is transparent for thicknesses less than 80 mg/cm², and is normally made light-tight by covering it with aluminium foil 0·003 mm thick; the small mass of phosphor ensures that the relative response to beta and gamma radiation is very small. The same geometrical considerations apply as were mentioned earlier for gas ionization detectors, and for thin sources the counting efficiency can be 20–30% of the total disintegration rate.

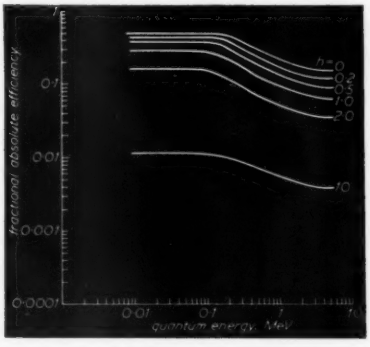
Two common phosphors

For beta counting the two phosphors in most common use are anthracene and thallium-activated sodium iodide NaI(Tl). The light output from NaI(Tl) is 1000 photoelectrons per MeV absorbed, compared with 400 for anthracene, and it is proportional to the beta energy dissipated in the crystal above a few keV, whereas anthracene is linear only above about 100 keV. However, due to the high mean atomic number of NaI(Tl) roughly 80% of the uncollimated electrons incident on one face will be scattered out of the crystal before being stopped; the figure for anthracene is 8–10%. This disadvantage may be overcome by inserting the source into a hole in the crystal when the geometrical efficiency may be as high as 80% for betas having an energy sufficient to penetrate the crystal shield.

The pulse spectrum from anthracene and NaI(Tl) can be counted from high energies down to 15–20 keV with very little correction due to the interval background, and hence the intrinsic efficiency for a beta particle entering the phosphor is essentially unity after making allowance for the possible loss in pulse height due to scattering. The background pulses are produced mainly by the spontaneous emission of electrons from the photocathode of the electron multiplier. The lower limit of 15–20 keV is reached only by an efficient optical coupling between the end face of the photomultiplier and the phosphor so that light scattered at the interface is minimized. High viscosity silicone oil has a refractive index close to that of glass and is often used. Loss of light from the side face of the phosphor may be reduced by packing dry MgO powder between it and the container walls.

The main advantage of NaI(Tl) becomes apparent when it is employed as a detector of gamma radiation. It is available in large transparent single crystals up to 3 in. diameter and 3 in. thickness, and more rarely up to even larger dimensions. The absorbing and detecting volumes are identical in this type of detector so that the large mass of phosphor coupled with its high mean atomic number results in a very high detection efficiency, especially at energies below 500 keV. Since the intrinsic efficiency for gammas is 1, as for betas, the overall efficiency of the system depends only on the geometrical factor and the absorption efficiency of the phosphor. The effect of energy resolution is too complex a subject to be discussed here.

An extensive computation of the *absolute* detection efficiency of different sizes of sodium iodide crystals has been made (7) for the case where a point isotropic gamma source is situated on the axis of a cylindrical crystal. A typical result is plotted in figure 12 for a crystal 1¾ in. in diameter and 2 in. thick when the source is located at different distances from one flat face of the crystal, the density of which was assumed to be 3·66 g/cm³. The geometrical factor is included in this result. The efficiency of the scintillation counter as a detector of neutrons has been fully covered previously (8) in NUCLEAR POWER.



Absolute efficiency of NaI(Tl) crystal 1¾ in. dia and 2 in. thick as a function of gamma energy for a point source on the crystal axis at various distances h cm from one end face (Fig 12)

References

1. Burtt, *Nucleonics*, 1949 (Aug) p 28
2. Putman, J., private communication
3. Bradt et al, *Helv Phys Acta* 1946, *19*, p 77
4. West, D. *Proc Nuc Phys* 1955, *3*, p 18
5. Abson, W. et al. *Proc IEE* 1958, *105B*, p 349
6. Abson, W. et al. *ibid*, p 357
7. Vegors et al. Philips Petroleum Co Research and Development Report *IDO*-16730
8. Owen, R. B. NUCLEAR POWER 1958 (April) p 166
9. General reference: *Nuclear Radiation Detectors* McGraw Hill

A British proposal is accepted as the latest European joint undertaking

DRAGON

details of the 10 MW HTGR

THE THIRD jointly-run project of the European Nuclear Energy Agency is a 5-year study programme on high temperature, gas-cooled reactors. Known as Dragon, it will comprise mainly a 10 MWe prototype reactor to be built in England at Winfrith Heath where a zero-energy HTGR has already been built by the UKAEA. Details of the agreement were given in last month's *Worldview*. The general arrangement of the reactor (figure 2) is that first proposed at the Geneva Conference by L. R. Shepherd (paper 314).

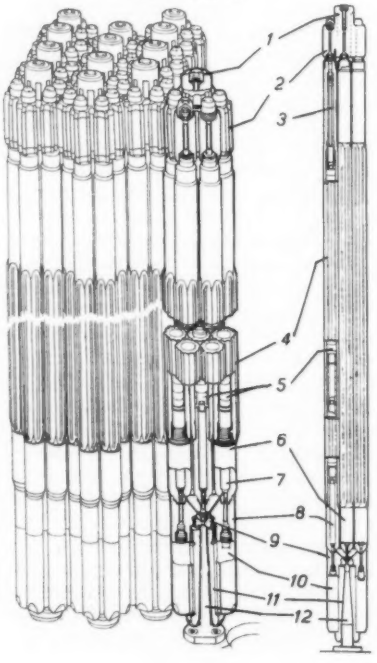
Hexagonal fuel array

The fuel elements are constructed from graphite, U-235, and thorium. Each consists of seven closely packed rods, united to form a hexagonal array, as illustrated in figure 1. Each fuel rod has a sheath of graphite on the outside and a mixture of moderator, fissionable and fertile materials inside the sheath. In the particular design illustrated, the mixture forms an annular fuel insert around a central graphite spine, but alternatively it could be in the form of a solid rod within the sheath. Each fuel rod contains at its upper end an inlet vent containing a porous plug through which a bleed flow of coolant gas passes, while at the bottom each of the seven rods is vented into a common duct in the block which holds them together and which seats on to a hollow mounting spike through which fission products are extracted.

Each fuel element is 8 ft long and the individual rods, each a little over 6 ft long, are sealed to the bottom block and retained with metal bolts. At the upper end, the rods are joined to a spider-shaped block by metal cap bolts and diaphragm washers to accommodate any unequal growth or expansion. An appreciable length change in an individual rod will not induce serious resisting forces since the diaphragm mounting washers will readily yield at the working temperature. The top block is shaped to position neighbouring elements and a lifting extension is provided for handling.

Sixty-one of the seven-rod fuel elements make up the core of the reactor, the actual core geometry being roughly a cylinder of 4 ft length and diameter. The closely packed rods have surfaces shaped to define a number of passages through which the coolant passes, the total voidage in the core due to these being approximately 13% of the total core volume. The fuel elements, of course, make up not only the 4 ft length of core but also the end reflectors, roughly 2 ft thick at each end. Around the assembled fuel elements is a side reflector made up of graphite columns 8 ft high with an overall diameter of 10½ ft. About 5% coolant voidage is provided in this side graphite.

Each fuel element comprises a hexagonal array of seven graphite-clad rods Drawing shows :
1. lifting extension 2. top block 3. porous plug admitting scavenging flow 4. fuel tube 5. fuel sleeve on graphite spine 6. fuel rod end plugs 7. graphite filler pieces 8. bottom uniting block 9. bearing plug 10. bottom extension block 11. mounting sleeve 12. mounting spike containing pipe to f.p. scavenge system (Fig 1)



Helium as coolant

Both the reflector columns and core elements stand vertically and are pivotally mounted on steel structural members inside a steel pressure vessel, the reflector being arranged to close onto the core to provide an expandable restraint at the top of the fuel elements. For a 10 MW output the coolant is helium at 10 atmospheres which enters and leaves by ducts near the top of the pressure vessel. The incoming coolant flows downward and maintains the inside of the pressure vessel and the bulk of the side reflector at a temperature not greatly different from the gas at 350°C. It subsequently flows upward through the core from which it emerges into a nimonic chamber at a mixed mean temperature of 750°C. The outflowing gas is transferred through a nimonic lined duct to the primary heat exchanger which is water cooled in the arrangement illustrated. It should be noted that the nimonic chambers and ducts are externally cooled by the incoming coolant and they have no structural function. No part of the primary circuit which has to withstand the full coolant working pressure is normally exposed to gas at more than 350°C.

Secondary cooling water emerges from the primary heat exchanger at a relatively low temperature, i.e. about 75°C, so that no excessive pressurization is required and a heat exchanger of small dimensions results from the large temperature difference between the hot gas and the cooling water. Other possible alternative arrangements using an intermediate heat transfer fluid to avoid any possibility of water leakage into the main circuit might be considered. No attempt to generate steam and power is contemplated in this study.

No shaft seals to be used

A feature in the primary cooling circuit is the proposal to avoid shaft seals and to use instead completely enclosed motors and compressors with gas bearings. It was not anticipated that a free-running gas turbine circulator would be developed in time to be used in this reactor experiment and the required pumping power, of the order of 100 kW, is so low that it would not provide a particularly useful exercise for the principle.

The inset view in figure 2 shows a single circuit with two circulators in

series, an arrangement which avoids control valves. However, alternative systems using parallel circuits are worth further consideration and a number of possible circulator and heat exchanger layouts should be examined before a final choice is made.

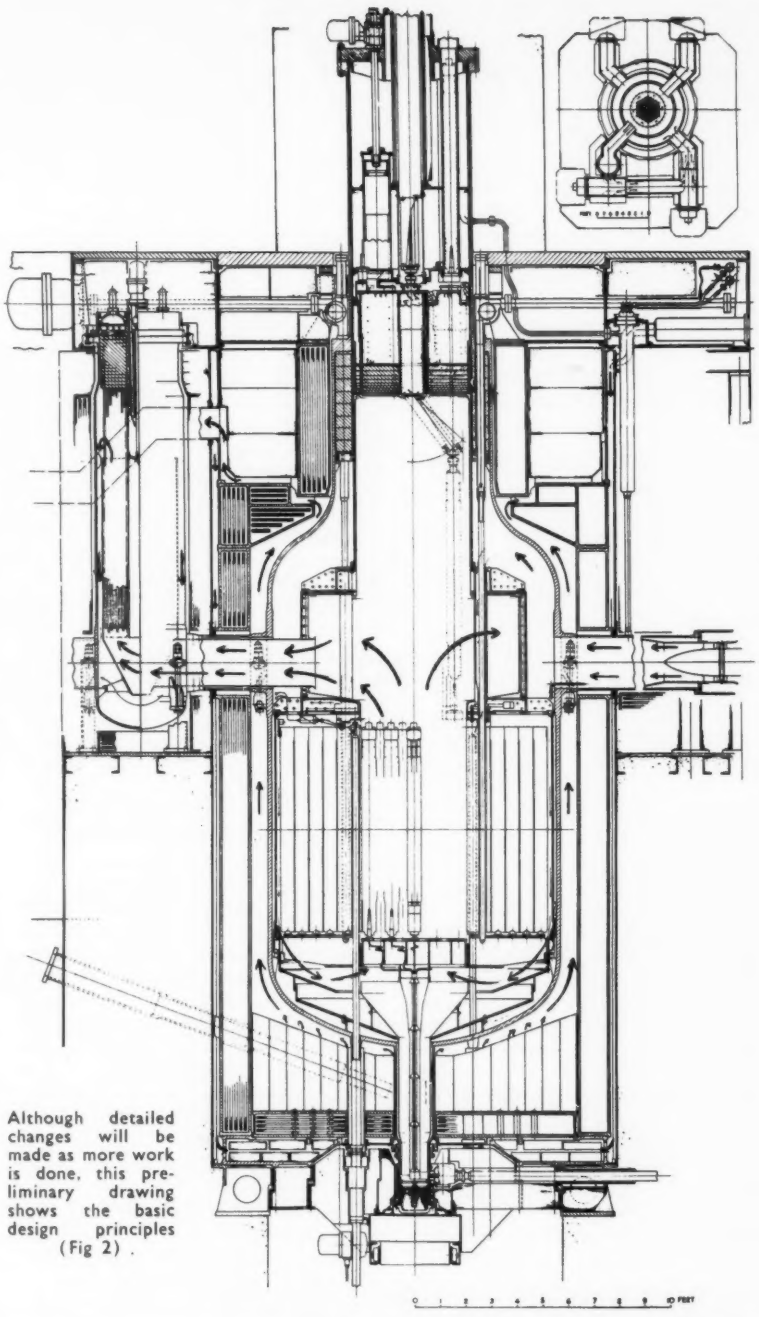
Control of the reactor is by a curtain of 30 absorbing rods moving in vertical channels near to the inside boundary of the reflector. These provide a small negative reactivity for shut-down and their removal compensates for temperature coefficient, poison and depletion, a total range of reactivity between 14 and 15% being controlled. The possibility of using boron as a burnable poison in the fuel inserts as a means of reducing the depletion compensation required from the control rods is also considered. It is proposed that the control rods would be actuated by cable drives with the provision of magnetic clutches in the winding mechanisms to release the cables in the event of an emergency shut-down requirement. In order to protect the actuators from any primary circuit activity, zirconium sleeves are provided which isolate these control mechanisms from the circuit gas and thereby simplify maintenance.

Fuelling through a gas seal

In a reactor of this type it is important to be able to load and unload fuel elements without disturbing the helium coolant in the primary circuit. Accordingly a charge/discharge machine capable of transferring elements through a gas lock is required and the lower end of such a machine is shown in figure 2. The relative infrequency of fuel charging would enable the work to be carried out at a convenient shut-down period when gas temperatures are low and pressure correspondingly reduced. During reactor operation the charge/discharge machine would be parked in a shielded position where the temperature is kept low by a cooled by-pass of gas which subsequently flows back into the reactor.

The fission products pumped from the bottom of the fuel elements are passed through a trapping system based on the use of active charcoal absorption beds. The emergent helium will still contain the longest period krypton and xenon activities since these are merely delayed. This gas will also go through a chemical purifier to remove O_2, CO_2, CO and H_2O before returning to the main cooling circuit. It is anticipated that the main problem in the reactor experiment will devolve around the effectiveness of the traps and chemical purifiers. If the oxidizing impurities in the primary circuit cannot be maintained in the region of a few parts per million, then the amount of mass transfer of carbon with unprotected fuel elements may cause embarrassment. Again, excessive radioactivity would set very stringent requirements on the leak tightness of the primary gas circuits which might be extremely difficult to meet.

It is not anticipated that the high outlet gas temperature will cause any major difficulties on the design of the pressure circuit, but the design solutions must satisfy not only normal running conditions but temperatures and pressures arising from certain postulated fault conditions. An appreciable but restricted flow of heat from the pressure vessel is desired to provide a cooling path in the event of primary circuit failure. Under such a fault condition excessive lagging could result in overheating of the pressure vessel, particularly if the reactor were not shut down; on the other hand an unrestricted heat flow would induce undesirable thermal stresses in the vessel. An adequate heat sink is available in the water-cooled thermal shield which surrounds the vessel.



Although detailed changes will be made as more work is done, this preliminary drawing shows the basic design principles (Fig 2).

The problem of high efficiency filtration in carbon dioxide circuits has been tackled in a number of ways. Basing their approach on a well-established technique, the use of miniature cyclone tubes, Mancuna have developed the units which will be used in Bradwell

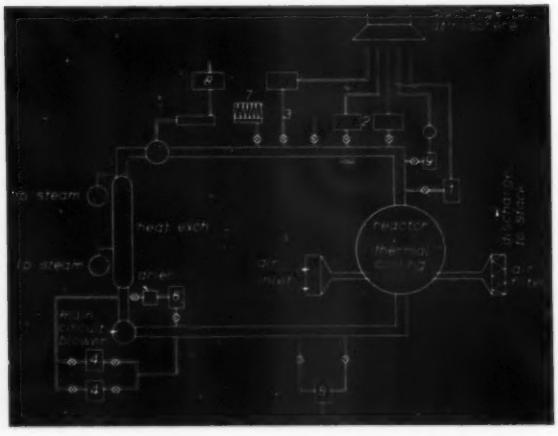
Dust removal in gas-cooled reactors

by R. A. Le PAGE

Managing Director, Mancuna Engineering Ltd

CONSIDERABLE RESEARCH has been carried out into various types of filter most suitable for the effective separation of fine particles of dust from carbon dioxide in a reactor circuit, the problems encountered here being quite different from the filtration of 'atmospheric' dusts where the air-conditioning type filter is suitable. Ceramics, porous stainless steel filters, fibreglass, etc, have been examined, but each have demonstrated various significant defects which rule out their exclusive use under one or more of the stringent conditions imposed. The known characteristics of the Mancuna-Dustex high efficiency miniature cyclone suggested that development of the basic cyclone tube might well provide the best overall solution to the problems envisaged if it could be proved that introduction of gases at extreme velocities did not create disturbance in air flow and thus reduce the known recovery efficiency.

Experiments reported in NUCLEAR POWER, January 1959, where the cyclone was tested at velocities of up to 600 fps resulted in a firm conclusion that no deterioration occurred and that, on the contrary, efficiency continued to improve. Throughout the range efficiency on a test dust all smaller than 13 microns and containing a proportion of sub-micron particles increased from 99·4% at 55 fps to 99·87% at 600 fps.

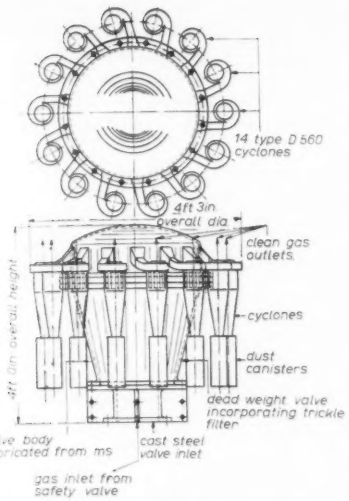


In a typical reactor circuit the dust control units needed are: 1. over-fill filter 2. CO_2 main relief valve filter 3. blow-down filter 4. by-pass filter 5. CO_2 charging filters 6. drier filter 7. blow-down air inlet 8. small filter for b.s.d. and leak line 9. filter for vacuum pumps (Fig 1)

Proved performance of cyclones

On this basis, and accepting the known features of the miniature cyclone, such as its cast construction from stainless steel or iron, its easy accessibility, freedom from maintenance and proved performance in industrial plant, the application of this equipment to the various dust separation problems encountered in the design of a nuclear power station was, in principle, acceptable. A detailed study of the individual problems was made and appropriate filters designed. While it is necessary to generalize somewhat due to variations in design of station and to certain factors which are still not precisely understood, e.g. the exact analysis of dusts which will be encountered in certain of the filtration points examined, the main applications studied are summarized below.

Dusts which are primarily iron oxide and graphite are entrained in the main circuit coolant through cor-



Mark I relief valve filter can take conditions of full flow, 10% simmer and leak flow (Fig 2)

rosion and erosion. A normal feature of standard design is the incorporation of a by-pass circuit to provide for the continuous filtration of a small percentage of the main gas flow. Situated across the main circuit blowers, the filtration equipment normally has a pressure drop available in the region of 6–8 psi. This being essentially a by-pass filter, with gas returning again and again for filtration, recovery efficiency requirements are not as stringent as in certain other applications. The recovery efficiency of 95% by weight of particles 10 microns and larger is, however, the minimum necessary and this should be improved upon if possible. Non-corrosive properties and 100% availability for the life of the plant are further necessary features.

Radioactive dust is critical problem

Carbon dioxide driers incorporated in the station would soon suffer damage from dust contamination. It is desirable to provide an additional filter, again on a by-pass circuit, to ensure filtration of dusts from the gas immediately prior to the drier. The pressure drop available for the filter is governed by the pressure resistance of the drier itself, but is normally of the order of 1–2 psi. Collector efficiencies required are similar to those for the by-pass filter.

While it is anticipated that the relief valve will only perform its function once or twice in the lifetime of a station—and, it is earnestly hoped, will never do so — the filtration of radioactive dusts in the event of a relief valve lifting and blowing direct to atmosphere is perhaps the most critical application facing the station designer and the dust engineer. It had been believed that ceramics or porous stainless steel would prove suitable, but this expectation, at least in so far as the exclusive use of these materials has been concerned, has not been realized. Considerable difficulties have been experienced and, under certain conditions, tests undertaken indicate the probability of unacceptable failure.

Exact nature of dusts unknown

The pressure drop available in the emission of gas from a relief valve is normally of the order of 40–50 psi, it being necessary to handle for brief periods a flow rate of anything up to 150,000 lb of CO_2 per hour at temperatures up to 600°C. The dust burden is likely to be variable. One difficulty in any examination of this problem is that the nature of the dusts which might be created, for example by combustion, is largely unknown, and no exact specification of particle size or even of physical and chemical properties has yet been made available. The requirement so far envisaged is that filtration of the discharge should be 100% at 10 microns with good efficiencies down to 2 microns. It is probable that the dusts likely to be created will include graphite, iron oxide, uranium oxide in some form or another and, conceivably, oxides of magnesium alloy or of other metals used in the manufacture of the fuel cans. It is also possible that the dust will be contained in either CO_2 gas or a mixture of CO_2 and steam, dependent on the type of breakdown; this could be due to reactor overheating or to failure in the heat exchanger.

A further complicating feature is that the filter for this duty must be capable of accommodating varying flow from full to leak flow from a safety valve which has not reseated correctly and, with certain types of safety valve, a further condition of simmer on valve opening which may be anything up to 10% full flow.

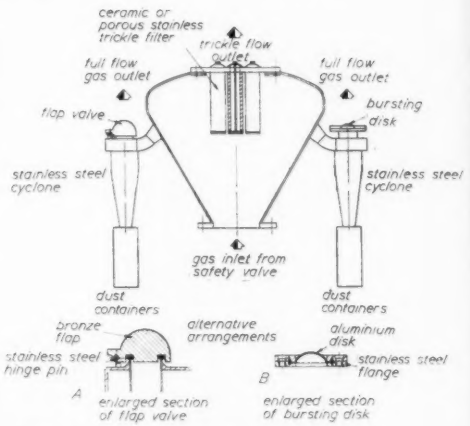
It is necessary for all gas entering the circuit to be filtered and for pressure in the circuit to be maintained. One filter is normally used for filtering gas entering the circuit from a state of vacuum and for pumping additional gas into the circuit to maintain pressure. In the one case, the filter is required to operate at full system pressure; in the other, from atmospheric pressure at a flow rate of 1–3 lb CO_2 per sec. A small pressure drop of between ½ to 1½ psi is normally available.

Filtration is again necessary when the CO_2 circuit is emptied. The nature of this filtration problem is entirely dependent on the characteristics of the circuit involved and requirements vary according to the individual designs of the several consortia. Figure 1 above illustrates the principal filtration points in a typical station layout.

Complex and comprehensive flow conditions must thus be catered for in any design of relief valve filter. Dust samples and analyses are not at present available in detail and design data must perforce be related to the use of a standard test dust such as Aloxite 125. Temperature conditions can again vary depending on the circuit.

Two relief valve filters

Two models of relief valve filter have been designed by Mancuna Engineering Limited, and are illustrated in figures 2 and 3. Both incorporate fundamentally a combination of cast

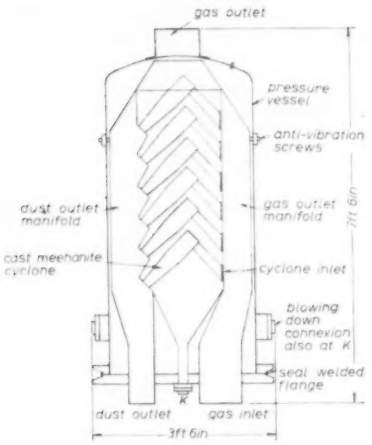


Basically similar to the Mark I the proposed D584 safety valve filter, incorporating a trickle filter, is more flexible and can be designed on the vertical basis shown here or a horizontal one (Fig 3)

stainless steel miniature cyclones and ceramic/porous stainless steel filters, either of the latter alternatives being used for the less stringent conditions experienced from simmer and leak flows. The relief valve filter Mark I, illustrated in figure 2, is designed to be able to accommodate conditions of full flow, 10% simmer and leak flow, while the Mark II filter, shown in figure 3, is devised for safety valves where simmer is not anticipated but where full flow and leak flow conditions are likely to be experienced.

The Mark I unit comprises a plate body, the top portion of which is flanged to take a removable shaped top cover; around its periphery are welded a number of high efficiency D584 cast stainless steel miniature cyclones of a new scroll inlet design; the casting of these cyclone tubes in stainless steel to fine tolerances is

an intricate job. The number of cyclones used relates directly to the pressure/volume characteristics of the discharge from the safety valve. The gas inlet at the base of the unit is flanged to connect to the ducted outlet from the safety valve. Internally in the body of the vessel is contained a 'dead-weight' valve especially designed to Mancuna's requirements. The 'weight' of this valve is arranged to take a small flow filter which can be in the form of ceramic or specially shaped porous stainless steel candles. The base of the 'weight' is drilled to permit gas flow through it into the filter medium; cleaned gas flows ver-



Eight by-pass filters of this design will be used at Bradwell. Operating conditions are: flow-rate 27 lb/sec CO_2, pressure 150 psi, temperature 200°C, pressure loss 4·5 psi (Fig 4)

tically through the filter in this 'dead-weight' valve and escapes to atmosphere via the cyclone outlet thimbles. This filter being designed to accommodate full flow, 10% simmer, and leak conditions, the ceramic or porous stainless steel elements are designed to operate at a gas flow up to 10% full flow from the relief valve beyond which the 'dead-weight' valve will lift, full flow being filtered direct through the cyclone tubes. When the safety valve closes, the 'dead-weight' valve closes and any subsequent leak flow from the safety valve will be filtered by the ceramic or stainless steel candles in the 'dead-weight' valve.

Horizontal or vertical model

Two alternative versions of the Mark II filter, illustrated in figure 3, are currently being considered. This filter is simpler than the Mark I and is applicable primarily where simmer conditions do not exist, but where full flow and very small leak flow must be accommodated. The filter is basically similar to the Mark I, but is subject to greater flexibility in layout and can be designed on a vertical or horizontal basis. The vertical arrangement shown comprises a similar body and top cover arrangement to the Mark I, but no 'dead-weight' valve is incorporated. Instead ceramic/porous stainless steel candles are fitted into the top cover with an outlet to atmosphere. The cyclone outlet thimbles can be fitted either with bursting discs or specially designed flap valves. The operation of this filter is that any leak flow from the safety valve will be directed from the sealed cyclone outlets to the ceramic/porous stainless steel candles and filtered prior to discharge to atmosphere. At full flow, the bursting discs will burst, or flap valve lift, permitting the cyclone tubes to filter the full flow of gas prior to discharge.

The flap valve arrangement has the advantage that as the safety valve reseats, the flap will close and any subsequent leak flow from the safety valve will be again handled by the secondary filter; with the bursting disc, any such leak flow will discharge via the open cyclone outlet thimbles direct to atmosphere. This would probably not be significant in that any dust entrained in such an escape would probably be of so small a particle size that it would not settle before losing its radioactivity.

Small dust containers are welded direct to the base of the cyclone tubes, as illustrated, to contain the dust recovered from the gas stream. It is anticipated that in the event of these filters coming into operation, the whole unit would subsequently require dismantling, cleaning and decontamination.

Blow-down filter

There are considerable variables in the requirements laid down for blow-down filters and little generalization as possible. Fundamentally, a filter in this application is a manually operated relief valve and efficiency requirements are similar to those specified for the relief valve filter. The application is again particularly suited to a combination of high efficiency miniature cyclone tubes and porous filters, although in certain cases a filter similar to the by-pass filter, to be discussed later, can be applied.

In the blow-down filter, efficiency is maintained until the pressure loss has dropped to ·25 psi with an inlet linear velocity of 55 fps. This necessitates the vacuum pumps being brought into operation when the reactor circuit pressure drops to ·25 psi. The unit will then continue to function satisfactorily until the vacuum in the circuit has reached a point where the linear velocity has dropped below 45 fps or approximately 10 to 20 in. Hg, according to the type of pump.

When a CO_2 circuit is being blown to atmosphere, should there be any dust particles entrained in the gas, the major proportion will be discharged to the filter in the initial release, when the heat exchanger and dusts are being swept at high velocity. The dust loading will drop rapidly after this initial discharge and at the later stages of the blow-down the gas should be clean, so that for the final discharge from 20 in. vacuum to 28 in. vacuum, clean gas will be passing through the filter, the efficiency of which will gradually be dropping off until zero discharge equals zero efficiency.

By-pass and drier filters

Pressure/volume factors remain constant and are not subject to significant variation. Recovery efficiency must, however, be of a high order and methods of removing recovered dust must be incorporated as separation of dust from a percentage of the main gas flow is a continuous procedure. Ceramics have been used in the less stringent conditions experienced here, but it is considered that there may be a loss of efficiency during the life of a plant. Cast iron cyclone tubes provide advantages in constantly maintained performance and an anticipated life equal to that of the station itself. Units have been designed and are to be installed, e.g., in the Bradwell nuclear power station, in which the cast cyclone tubes are assembled between front and back plates and inserted into an all-welded assembly, the design of which provides an air inlet and outlet, a dust outlet and, to meet CEGB requirements, a special deposition outlet. The whole assembly is encased in a pressure vessel with blowing down connexions for use in the unlikely event of cleaning becoming necessary.

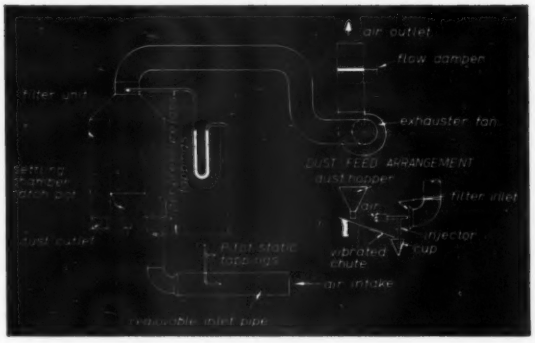
The drier filter is a similar unit, the number of tubes being determined by the volume of gas to be handled and pressures available. A typical by-pass filter is illustrated in figure 4. Each of these two types of filter can be fitted with a special device for unloading the unit and collected dust.

Data on Bradwell units

Tests have been finalized on the drier filters being supplied for Bradwell and while details of the filter duty cannot be divulged, a description of the test and resultant data is given below.

The filter comprises a block of four cyclone tubes held in a sheet metal frame, the whole of it enclosed, as

described above, in a pressure vessel. A test rig (figure 5) was erected by fitting an exhaust fan to the outlet of the filter casing and a bend on to the filter inlet. A long, straight tube was fitted to the inlet for flow/pressure drop tests. For efficiency tests, this tube was removed and the dust fed directly into the inlet bend from a dust feed arrangement. This consisted of a hopper which dropped the test dust on to a vibrated chute. The dust moved slowly along this chute and fell into a cup from where it was picked up and fed into the filter inlet by an air injector. Air flow through the filter is adjusted by a damper in the fan exhaust and dust flow can be adjusted by the vibrator speed.



Overall efficiency tests on the Bradwell drier filters were performed with this rig. An exhaust fan was attached to the outlet of the filter casing and a bend on to the inlet to which a long straight tube was fitted for flow/pressure drop tests (Fig 5)

The flow through the filter was set at various values by means of the damper, and corresponding readings of flow and filter pressure drop were taken. The rig with the long inlet pipe had previously been calibrated by means of a pitot traverse (using a two-liquid manometer) and the flow was determined from this calibration by taking a single pitot reading at the mid-point in the duct. The filter pressure drop was measured by a water manometer from single point tappings in the inlet and outlet manifolds.

It was agreed that a fractional efficiency test which would necessitate the collection and size analysis of numerous dust samples was unnecessary and an overall efficiency test, carried out with a test dust the bulk of which was below 10 microns, was considered appropriate. High overall efficiencies from this test would indicate that high fractional efficiencies would be obtained from coarser particles. The test dust chosen was Aloxite 125, an optical grinding powder prepared by The Carborundum Company having the following size analysis:

PARTICLE SIZE, MICRONS	PERCENT BY WEIGHT
5·0	8
7	28
8	50
10	86
12	98
13	100

specific gravity 3·9

Samples of this dust weighing 200 grammes were fed into the filter inlet by means of the vibratory feeder with the total air through-put adjusted to 3·28 cfs. The separated dust was retained during the test by a blank flange with a rubber joint in the bottom of the dust outlet pipe. The dust which escaped separation passed to atmosphere.

Six tests were performed with the results shown in Table I.

The fluctuations in efficiency were due to the variations in the amount of dust dislodged from rapping the filter casing after each test and clearly some of the dust lodged in previous tests was dislodged during test 5 giving '100·1%' efficiency.

TABLE I *Results of tests performed on Bradwell drier filters*

TEST NO	TIME *mins*	WEIGHT OF SAMPLE FED *grams*	WEIGHT OF SAMPLE CAUGHT *grams*	WEIGHT OF SAMPLE LOST *grams*	EFFICIENCY (OVERALL) %	TOTAL AIR THROUGH-PUT *ft³/sec*	DUST LOAD *grains/ft³*
1	6	200	197·5	2·5	98·75	3·28	2·6
2	12	200	199·8	0·2	99·9	3·28	1·3
3	7	200	197·5	2·5	89·75	3·28	2·24
4	6	200	198·1	1·9	99·05	3·28	2·6
5	6	200	200·2	0·2 gain	100·1	3·28	2·6
6	6	200	198·9	1·1	99·45	3·28	2·6
Totals		1200	1192·0	8·0			
Mean					99·33		
Mean of tests 4, 5 *and* 6					99·5		

No dust was found in the settling chamber catch pot and none fell from the inlet manifold when it was struck with a mallet. This indicates that the lodged dust was in the outlet section of the unit from where it could not be re-entrained and would finally fall into the dust collecting hopper. Deposits could, in fact, be seen on the sides of the dust outlet pipe.

The air rate of 3·28 cfs was that required to simulate actual working conditions and was deduced on the basis of tests carried out by the BCURA (Information Circular 98—*Investigation into the effect of temperatures and pressure on the collection efficiency of cyclone dust separators*). This work established that efficiency tests at atmospheric conditions will be representative of actual working conditions provided the ratio of inlet velocity to viscosity is the same in both cases.

The volume per cyclone tube used in these tests was below the minimum throughput figure at which performance had been guaranteed and the varying dust loads in the tests were in excess of that specified. The average overall efficiency from the last three tests, which are the most relevant due to the initial build-up of dusts as described before, on a test dust the bulk of which was below 10 microns, shows that fractional efficiency approaching 100% should be achieved on all particles above this size. The tests indicate that this filter is entirely acceptable for the duties of drier filtration and that its recovery efficiency is of an extremely high order.

Charge and re-charge circuit filters and overfill filters

The miniature cyclone tube is particularly suitable for the duties encountered in these applications, and in the case of the charge and re-charge filters, the unit is basically similar in design to that used in the by-pass and drier filters. The comparatively small pressure drop available nevertheless permits a very high recovery efficiency to be achieved with the Mancuna-Dustex tube.

The overfill filter is very small, its capacity requirements being of the order of 40–50 lb CO_2 per minute. The efficiency required is, however, at the same level as the relief valve filter. A single cyclone tube, specially designed to Lloyd's Class I, is available for this application. All other Mancuna filters are generally to Lloyd's Class II, although units can be designed to Class I if specified.

Acknowledgment
The author is grateful to R. M. Dobson for assistance in preparing the technical data.

Cross Section by GRACCHUS

GOING it more or less alone on nuclear energy, Ruston and Hornsby have from the start believed in 'getting their hands dirty' rather than just putting up a nameplate and waiting for something to turn up. This practical philosophy was explained to me recently by Ruston's technical director Bob Feilden and I am sure it's the right way to go about it. Feilden was of course brought up this way, for after coming down from Cambridge he joined Frank Whittle's jet engine team in its early hectic days when dirty hands was the only way to get the thing going. After the war he was the man behind Ruston's very successful TA gas turbine, some 100 of which, I understand have been sold all over the world.

With this background it is no wonder that when it comes to nuclear power Ruston's are not much interested in temperatures in the 400's. Give them something like 1000°C and they will be very happy indeed—at least that's the impression I got. The Ruston gas turbine is a ready-made power plant for an HTGR.

During my visit Ruston's nuclear project engineer Michael Wood showed me their little gas bearing circulator running in the open. This was described in our December 1958 issue. In the noisy background of a machine shop I could not hear it running and the only evidence of motion was the draught from the open impeller.

ONE of the most comprehensive reviews of the reactor metallurgy situation was given recently to the Joint Panel on Nuclear Marine Propulsion by Monty Finniston, until lately head of metallurgy at Harwell but now research manager at C. A. Parsons' new nuclear research centre in Newcastle. I was most surprised however to find that in his section on the behaviour of structural materials under irradiation he had drawn almost exclusively on the Geneva paper by L. P. Trudeau of The International Nickel Co, Toronto. Trudeau's paper is certainly a very good one but it is confined to steels made to American specifications. There must, I am sure, be quite a body of experience in this country on British steels and I'm certain his audience would have sooner learned about their behaviour. Dear old commercial security strikes again.

International Nickel—as commercially-minded a body as one could hope to meet—do not apparently consider it damaging to present this excellent paper, and the same might be said about almost any transatlantic company. Yet here we have all this cloak and dagger business. I used to think America was the land of real trade security but now, compared with ours, US firms are positively verbose.

IT'S not often, I imagine, that one finds a scientific experiment rigged up on a managing director's desk but Mr L. A. J. Gardiner of Western Detail at Bristol has just that. But then Gardiner is no ordinary managing director. The apparatus in question centres on a small resistance furnace for which he has developed a control system capable, he assures me, of maintaining the temperatures to plus or minus half a degree at any preset value up to 1200°C. It covered so much of his desk that there was simply no room at all for its normal functions. When I asked him why he did these experiments in office instead of in the works he replied it was more comfortable to work there. Which is a very good reason indeed.

THE first international symposium on nuclear fuel elements which was held recently at Columbia University under the joint sponsorship of Columbia and Sylvania-Corning Nuclear Corporation seems to have been a most interesting function according to Dr Greenough who reports the conference in this issue. It is however rather extraordinary that there was only one British delegate—Greenough himself, deputizing for the Risley chief metallurgist H. K. Hardy who was taken ill just before leaving for the States. Surely at a conference of this importance we should have had a few more delegates? I don't suppose there's a great deal we could tell the Americans about fuel elements but I'm sure there's a lot to learn.

THE fact that HMS *Dreadnought*—originally conceived as a 'do-it-yourself' job—is now to be virtually all-American, with a Westinghouse S5 reactor and a *Skipjack* hull only means the getting into step of a project that to all appearances started on the wrong foot. The Admiralty and the Government have of course come in for a lot of ribald and sometimes bitter comment over the sea-change that the Royal Navy has suffered. I feel however that more lies behind this than is apparent on the surface and that the first step might have been really quite a sound move. Suppose for example we had done nothing whatever about a submarine project on our own account—just sat and looked appealingly at the Americans? It would probably have taken an actual war to get an atomic sub that way. No, far better to have a go and show at least determination and some progress with a PWR of our own.

Now the Westinghouse-Rolls-Royce deal is tied up, what next? It would be a perfectly logical move for the military agreement to flourish into a full-blooded commercial deal. Who knows, we may yet see a Shippingport alongside Calder Hall.

WHEN are we going to get a realistic overall fuel policy? Ten years ago we were desperately short of indigenous fuel and of foreign exchange to import it. A great deal of money was poured into colliery modernization and the annual output inched up slowly although it has now levelled off. The electricity authorities considered there would never be enough coal to satisfy them, so oil-fired stations were planned and some actually built. Came Suez, and we decided to reconvert to coal wherever possible and to build no more oil-fired stations. Now it seems we have too much coal and the NCB proposes closing down 36 uneconomic pits. This causes an outcry among the miners who call for a slowing down or even halting of the nuclear programme. So where on earth are we? The miners affected by the pit closing have a lot of sympathy on their side and the Coal Board a tough social problem on their hands. But the miners' demand for a cut back in nuclear power amounts to sheer Luddism. I believe the idea of nuclear power has been sold to the country at large and in any case it is in no sense competitive with coal which for as long as we can see will be needed for many purposes beyond mere combustion.

On Record

Heavy water reactors . . . are the only practical reactors which can burn natural uranium, a universally available and low cost fuel.—John Menke, President, Nuclear Development Corporation of America.

There are no apparent advantages to the use of heavy water at present prices.—W. Kenneth Davis, Vice-president, Bechtel Corporation.

Mr Dulles is radioactive.—London Daily Mirror.

Mistakes.—Title of lecture given by E. Walshaw to The Institution of Production Engineers.

Collisions.—Title of lecture given by Professor H. S. W. Massey to The Physical Society.

A study of single-zone U-233 thoria reactors

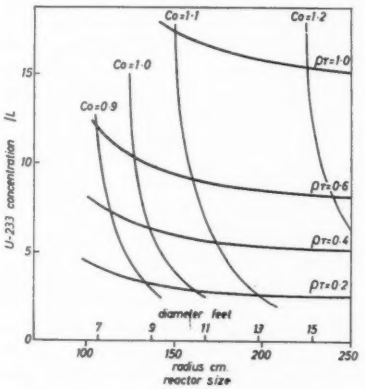
by W. G. CLARKE, *AERE, Harwell*

A consideration of single-zone and two-region aqueous homogeneous breeder reactor systems was carried out in 1954, and a decision taken to concentrate on the latter. This rested primarily on the engineering difficulties of the very large pressure vessel which was thought to be necessary to obtain conversion factors in excess of unity in the single zone reactor, and also on its large investment of fissionable material. Recently however the situation has again come under review and this paper is an attempt to reassess the physics of the single-zone system.

The reactor is assumed to be an unreflected sphere 7–15 ft dia and to contain a slurry of thoria, with U-233, in heavy water at a concentration between 200 and 1000 g/l, the mean temperature being 265°C. For ease of comparison with the similar two-zone systems the protoactinium loss is based on a total thermal power of 400 megawatts from the reactor.

Since the reactor is a fairly large unreflected sphere and the moderator is heavy water, it was decided to treat the criticality on a simple Fermi age diffusion model. The difference to the results had the standard two-group treatment been used is very small indeed; it would give slightly lower concentrations and masses, and higher conversion factors.

The system is homogeneous and uranium concentrations are quite low, so fast fission was neglected and the resonances in U-233 allowed for by using an effective cross-section which includes epithermal absorption. The slowing down area (age) in the slurry is assumed to be the same as that in pure moderator, the scattering in the thoria compensating for its displacement of heavy water. The resonance escape probability is calculated using the effective resonance integral of



Variation of U-233 concentration and conversion factor. Co = conversion factor; ρ_T = thoria density kg/l

thorium in a simple formula. The uncertainty here is the cause of a large part of the inaccuracy of the results, as was true of earlier studies.

It has been assumed that the fuel is pure U-233, containing no higher isotopes; more detailed calculations show that it may be assumed that their effect is self cancelling; that is, that the neutrons produced by them balance the neutrons lost to them.

The method involves choosing a reactor size and thoria concentration and then solving the equations directly for uranium concentration, the conversion factor being deduced afterwards. Rather than limit the results to only one particular level of fission product poisoning, this and the breeding loss due to neutron capture in protoactinium are treated as small effects altering the system only slightly, thus enabling any low level of poisoning to be allowed for.

Results of the study show that single-zone homogeneous aqueous reactors seem much more attractive on the basis of these present calculations than previous results seemed to show. Most of the difference is attributable to the more recent data on thorium resonance integral and to the use of an effective cross section for U-233 which includes an allowance for epithermal neutron absorption.

The mass invested in the core and circuit is seen to be about one to two hundred kilograms of fissionable isotope—about equivalent to a year's burnup. The minimum usable size of pressure vessel remains larger than that for the two-zone reactors but not very much so. About 12 ft diameter gives very attractive performance from the reactor physics point of view. This article is condensed from UKAEA report no. R/R 2537.

Activity build-up in PWRs with stainless steel elements

by WALTER H. ZINN *et al*, *General Nuclear Engineering Corpn*

One problem with pressurized water systems is that long-lived radioactive deposits tend to build up on the surfaces of the primary loop. On portions of the loop outside the core these deposits may reach levels high enough to hamper maintenance. This problem is intensified if stainless steel is used in regions of high flux. Cobalt-60 is produced by n-γ reactions on Co-59; both Co-58 and Co-60 result from n-p reactions on nickel.

Accordingly, a research programme has been undertaken on the Army Package Power Reactor, the first PWR with stainless steel fuel elements and primary system. This work is being done by Alco Products, Inc, Schenectady, New York (*2–6*).

Activity outside the core could stem from several causes: fission products from defective fuel elements; fission products from uranium present in the cladding either as an impurity or as a contaminant added during fabrication; the products of n-γ or n-p reactions on the water or impurities in it; or activated corrosion products. The products of water activation are not long-lived; and demineralized water,

free from impurities such as argon-41, is used in the APPR. Therefore, in the absence of serious fission product concentrations, activated corrosion products are the activity source of primary concern. The insoluble corrosion product nuclides with relatively long half-lives are of greatest interest (Table I).

TABLE I *Insoluble corrosion product nuclides*

NUCLIDE	HALF-LIFE	γ-ENERGY (MEV)
Co-58	72 days	0·81
Co-60	5·25 years	1·17, 1·33
Fe-59	45 days	1·1, 1·3
Mn-54	310 days	0·835
Cr-51	26 days	0·267

It is important to note that Co-58, not Co-60, dominates when stainless steel cladding is used. Type 304, used in the APPR, contains 8·0–11·0% nickel, 6·0% of which is Ni-58. Reducing cobalt impurities would decrease the Co-59 (n, γ) Co-60 activation, but the nickel is an essential constituent of the steel.

Difficulty of prediction

The ultimate goal of any theoretical approach is two-fold: to predict the activity level of the primary water and the activity deposited on the primary system components. However, the complexity of the many mechanisms in action has so far prevented reliable predictions. As an example, there is fundamental disagreement as to the relative importance of the corrosion products which are activated in the core and then dislodged, and those which come from out-of-flux regions and are activated while passing through the core.

The usual approach has been to attempt to predict the activity of the water (and suspended particles) as a function of reactor equivalent full power hours (EFPH). Various equations have been derived, using the following simple material balance: rate of accumulation = rate of formation − rate of removal.

The removal mechanisms incorporated, include radioactive decay, purification or filtering, and sometimes deposition on the primary loop surfaces. The equations are recognized as approximations—they are based on assumptions such as a constant ratio of the removal rates due to purification and to deposition, and various relative contributions from in-flux and out-of-flux regions. Further, the equations do not include the effect of n-p reactions, flow rate, temperature, pressure, pH, and many other parameters.

Even if the level of water activity could be accurately predicted, the problem of determining the deposition rate throughout the primary loop would remain. This problem would involve the effects of many additional variables.

The only reliable way to predict the activity build-up and maintenance problem is to conduct an experimental programme. This is now in progress on the APPR and has included measurements of:

a. Intensity of the radiation field at the steam generator tube header sheet.
b. Activity of samples of primary water.
c. Activity of samples of crud filtered from the primary water.
d. Intensity of the radiation field at various external points on the loop.
e. Activity deposited on metal test coupons exposed to the primary water.

One object of the programme is to correlate measurements b–c with measurement a, which is difficult to obtain. Data obtained thus far have been erratic, and conclusions must be regarded as tentative. It should be noted that the primary water sampler, the crud probes, and the test coupons were located in a one-inch purification line which parallels the twelve-inch primary water line. It is entirely possible that non-representative samples are responsible for the erratic data. In spite of this difficulty, some very interesting conclusions can be drawn.

Identifying nuclides

The five expected nuclides—Co-58, Co-60, Mn-54, Fe-59 and Cr-51—were identified in the water samples. Very early in the test the ratio of Co-58 to Co-60 was about 10:1; but it has now decreased to 3:1. The longer half-life of Co-60 explains this behaviour. In fact, if decay were the only removal mechanism in operation, the value of this ratio would be expected to keep on decreasing for some time; but this is not the case. Lack of knowledge of the relative strengths of the various removal mechanisms prevents prediction of its rate of change and final value. This situation is an example of the general difficulty discussed earlier.

The same active nuclides were identified in the filtered crud samples. The specific activity of the crud (disintegrations per minute per milligram) increased with time.

The external radiation dose rate values, though somewhat erratic, indicated clearly an increase with time. The techniques used have been considerably altered and future data should be much more easily interpreted.

Data taken early in the programme indicated that the dose rate at the steam generator tube header sheet near the end of the first core life might be as high as 20 or 30 r/h; but later data have been much more encouraging. The dose rate measured at the header sheet after more than 7000 EFPH was about 2 r/h. This dose rate does not seem serious at first glance; however, the increasing specific activity of the crud indicates that the activity build-up will probably not be linear.

Of the methods employed to investigate activity build-up, the most promising was to expose test samples, known as 'coupons,' to primary water. Facilities for these tests were not available at the beginning of APPR operation, however, and only a few complete analyses have been made so far. The activity build-up is most rapid on Croloy 16-1, intermediate on carbon steel, and slowest on 304 stainless. The deposits on Croloy 16-1 metal are the most difficult to remove. It is probable that finish and other metallurgical aspects are important in determining the rate of build-up. It was discovered that higher temperature exposure (440°F) resulted in considerably higher deposition rates than those at lower temperature exposure (100°F).

Design of a second core for the APPR has been strongly influenced by the studies of the build-up problem. To reduce the Co-60 activity, which arises partially from n-γ reactions on Co-59, a low-cobalt 304L steel has been specified, and the Haynes Stellite flux suppressor combs used in core 1 have been eliminated. Samples of the 304L cladding in core 1 contained 0·05 w/o cobalt; and 0·005 w/o has been specified for core 2. This restriction increases the cost of the steel by a factor of two. The decision not to use 347 stainless steel in core 2 was based partially on an analysis (*8*) which showed that tantalum-182 activity would be too great a problem.

Decontamination procedures

Since it is unlikely that activity build-up can be suppressed, it is important to develop decontamination procedures. The Westinghouse Atomic Power Division is one of the more active groups in this field. They have proposed decontamination solutions and procedures for the Shippingport Pressurized Water Reactor (*9*). Two of their developments are given in Table II.

Fill-and-flush operation is accomplished by filling the coolant loop, pumping the solution around, and then draining and flushing the loop. This can be repeated if necessary. Feed-and-bleed operation is accomplished by continuously adding solu-

tion and draining it off until decontamination is complete. It has been found that reducing solutions have more effect on corrosion products than on uranium dioxide, whereas the reverse is true of oxidizing solutions.

Reference *10* gives the results of high temperature tests of many reagents and of their effects on 304 steel. At 300°F, paraperiodic acid, citric acid, and the disodium salt of EDTA appeared suitable. The order of corrosive attack of these reagents was 1 mg/dm² for a three hour test (*7, 11*).

Decontamination studies have been in progress as part of the APPR Experimental Programme since February 1958. Excellent decontamination factors have been obtained in experimental loops.

No pressurized-water reactors now in operation include facilities for decontamination without lengthy preparation and procedure. If further experimental work at the APPR reveals that the problem of deposition of radioactive corrosion products is as serious as it now appears, it may be advisable to incorporate integral decontamination equipment in future reactor designs.

TABLE II *Westinghouse decontamination solutions*

Concentrated solutions for fill-and-flush operation. Temperature of treatment 200–250°F

COMPONENT	OXIDIZING SOLUTION	REDUCING SOLUTION
Hydrogen peroxide	3 g/l	
Acetanilide	1·5	
Hydrazine		5 g/l
EDTA	3·5	3·5
Sulfamic acid	12	25
Hexamethylene-tetramine	1	1
pH	1·5	1·5

Dilute solutions for feed-and-bleed operation. Temperature of treatment 250–300°F

COMPONENT	OXIDIZING SOLUTION	REDUCING SOLUTION
Hydrogen peroxide	0·3 g/l	
Acetanilide	0·10	
Hypophosphorous acid		0·5 g/l
EDTA	0·15	0·15
Sulfamic acid	0·25–0·5	·25–0·5
Hexamethylene-tetramine	0·1	0·1
pH	1·8 –2·2	1·5 –2·0

References

The AEC reports listed below are available for inspection at AEC depository libraries and are sold by the Office of Technical Services, Department of Commerce, Washington 25, D.C.

1. *Phase III Design Analysis for the Army Package Power Reactor*, Vol. 1 & 2 APAE-10, Aug. 15, 1956. (AEC report) $6.50
2. W. J. Small and others, *Long-Lived Circulating Activity in the Army Package Power Reactor*, APAE-20, Aug. 28, 1957. (AEC report) $1.00
3. A. L. Medin, ed., *Literature Survey for Activity Build-Up on Reactor Primary System Components*, APAE-25, Jan. 15, 1958. (AEC report) $2.25
4. J. L. Zegger and others, *Radiochemical Analysis of Crud from the Army Package Power Reactor*, APAE-26, Feb. 15, 1958. (AEC report) $6.30 (ph), $3.00 (mf)
5. *Corrosion Product Activity in the Primary System of the Army Package Power Reactor*, APAE-29, April 15, 1958. (AEC report) (price to be determined)
6. A. L. Medin, *Review of the Corrosion Product Radioactivity Programme at the Army Package Power Reactor*, APAE-31, April 25, 1958 (AEC report) $3.30 (ph), $2.40 (mf)
7. R. Lloyd and W. T. Lindsay, Jr. *Decontamination of WAPD-29 Loop*, WAPD-CDA(AD)-48. (AEC report) $6.30 (ph), $3.00 (mf)
8. E. E. Gross, *Estimate of the Ratio of Ta^{182} to Co^{60} Activity Expected in the APPR-1 core*, CF-58-2-32, Feb. 10, 1958. (AEC report) $1.80
9. *Proposed Procedures for Chemical Decontamination of PWR*, WAPD-PWR-CP-2719. Westinghouse Electric Corporation, Bettis Plant
10. H. A. Droll, *High-Temperature Stability of Aqueous Solutions of Reagents that are Potentially Applicatory to PWR Decontamination Processes*, WAPD-PWR-CP-2079
11. R. S. Gilbert and W. T. Lindsay, Jr. *Chemical and Radiochemical Evaluation SIW Decontamination Test*; WAPD-CDA(AD)-376. Westinghouse Electric Corporation, Atomic Power Division. (To be published)

Nuclear Technology | Instrumentation

An all-steel gas proportional counter

by DENIS ALIAGA-KELLY, *Plessey Nucleonics Ltd*

Gas proportional counters are sometimes required for certain specialized nuclear counting applications, when they can show advantages over the more common geiger or scintillation counters. Their especial advantages are:

1. A certain degree of energy resolution is obtainable with a proportional counter, enabling it to be used to discriminate between particles or quanta of different energies.
2. The proportional counter can be used efficiently at quite high counting rates, and resolving times of 1 microsecond are readily obtainable.
3. When correctly designed, proportional counters can operate at higher pressures and temperatures than geiger or scintillation counters.

A disadvantage of the gas proportional counter is the requirement of a very stable EHT supply, compared with the geiger counter, but such stable supplies are required for use with scintillation counters and are available.

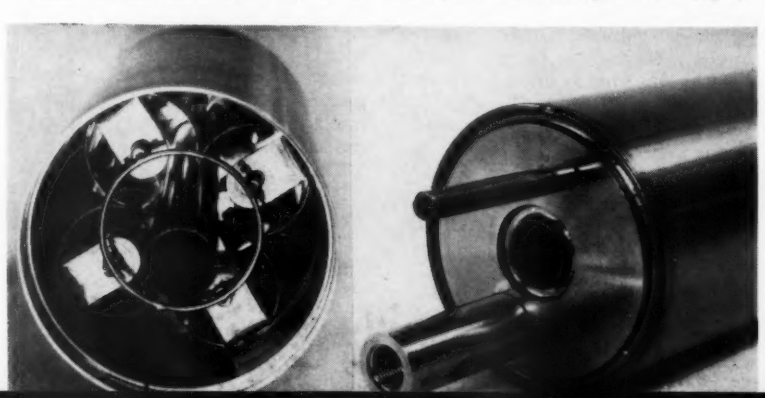
A gas proportional counter designed for a particular application is shown in Figure 1. This unit is constructed throughout of stainless steel and is, in fact, a 4 π counter in which four counting annuli surround a central thin tube which forms the window of the counter. The anode wires are 0·00254 cm. (0·001 inch) diameter tungsten, and the insulators are of the metal-to-ceramic type. All welds are made by the argon-arc process which yields very good results provided the joints are properly designed and fit closely together.

The strictest precautions must be taken to clean thoroughly all the components of the counter and to maintain this condition throughout assembly. It has been found necessary to bake out the counters at about 300°C whilst evacuating them on the vacuum pump, to ensure that gases absorbed on the inner metal surfaces are released and removed as much as possible by the pump.

The central tube which forms the 'thin window' of the counter has a wall thickness in the order of 0·015 cm. (0·006 inch). This thickness determines the minimum energy of beta particles from a source placed within the tube which can be detected in the counter—in this case the minimum energy is about 0·4 MeV.

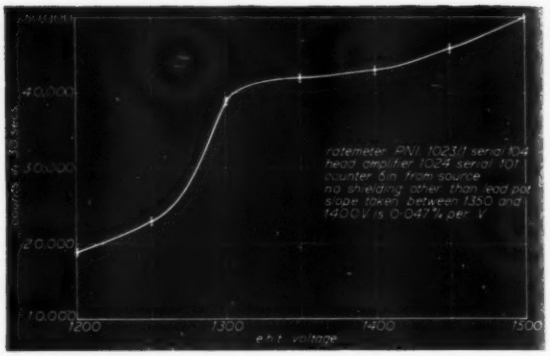
The gas filling can be varied depending on the application. For the counter illustrated mixtures of very pure argon with either very pure methane or ether have been found satisfactory and the pressures are in the ratio of about 25 cm Hg of argon to 4 cm Hg of methane or ether, while the total pressure is adjusted to

Interior of the counter (left) shows the four counting annuli surrounding the centre window tube. Right, top end of the complete tube showing the weld (fig 1)



allow the counting plateau for beta particles from a Sr-90 source to lie in the EHT ranges of 1300–1500 V. A typical plateau obtained under these conditions is illustrated in Figure 2.

The counter illustrated in Figures 1 and 2 is used in the Plessey rod-type burst fuel element detector. This instrument is used to detect by their emission of beta particles solid fission products on a rod, where they are deposited by an electrostatic field when they decay from the gaseous to solid form in a precipitation chamber adjacent to the gas proportional counter.



A typical plateau obtained with a Co-60 source in a 2-in. lead pot (fig 2)

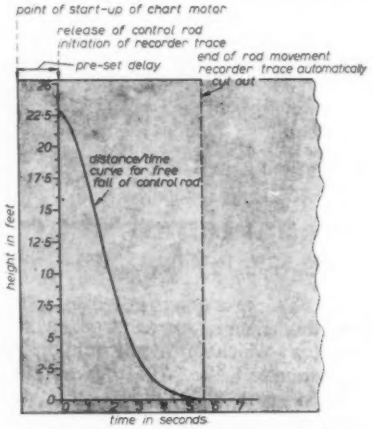
Control rod recorder

traces dynamics of drop

A quick-release mechanism is incorporated in the control rod winding heads of the Bradwell gas-cooled reactor to ensure that the rods can be rapidly lowered for an emergency shut-down. The speed of fall must however be carefully controlled so that the rods reach a specified minimum rate without falling fast enough to damage the winding gear and reactor equipment. This is done by fitting eddy-current brakes to the winding heads. After these brakes are set a speed/time curve is prepared for the drop of each individual rod to make sure its dynamic characteristics conform to a specified standard.

Special recorders, known as rod drop recorders, are made by the Cambridge Instrument Company for preparing these speed/time curves.

The instrument is a slightly modified version of the standard Cambridge high-speed electronic recorder. This is a self-balancing potentiometric recorder incorporating a powerful closed-loop servo-mechanism with a high response speed and velocity feedback. For rod-drop recording the standard slide-wire of the potentiometric circuit is replaced by a magslip receiver. Error signals, caused by differences in position between the magslip receiver and a magslip transmitter fitted to the winding mechanism of the control rods, are fed into the recorder amplifier. This drives the servomotor and hence the receiver rotor and the recording pen until the balance is restored. The recorder trace thus indicates the curve of the fall of the control rod. A test circuit is incorporated in the recorder for checking its operation before the rod is released.



Characteristics of a control rod drop

Preparing a rod drop curve is a completely automatic operation from start to finish. The operator depresses a single ' start ' button that starts both the recorder and the dropping mechanism and switches off and re-sets the recorder at the end of each operation.

The Cambridge Instrument Company acknowledge with thanks the help and information provided by A. Reyrolle & Company Limited, who also supplied the illustration.

Nuclear Technology | Materials

Developments in pvc plasticizers

irradiation results show promise

Elastomeric materials used for flexible sheathings and coverings in the construction of atomic power stations and laboratories have to operate at somewhere near ordinary temperatures (0° to 30°C) under gamma (and other) radiations from nearby radioactive materials. The behaviour of plasticized polyvinyl chloride under intense gamma radiation was recently investigated by the Atomic Energy Research Establishment in conjunction with The Geigy Company Ltd, and the report on this joint work (AERE Report No. E/R 2518: *The degradation of plasticized PVC compositions under high level gamma radiation*)* showed that the useful life of the PVC is markedly affected by the type of plasticizer used, the best of those so far examined being tritolyl phosphate (TTP: formerly called tricresyl phosphate).

Geigy now report that they have compared the behaviour of TTP with that of their trixylyl phosphate (TXP) and have found no significant difference between the two in respect of radiation resistance. TXP can thus be used in place of TTP in this field—a fact of interest to industry in view of the economic advantages offered by TXP.

The comparison of TTP with TXP was made under conditions similar to those of the earlier investigation, except that the composition used contained 35% of plasticizer (instead of 40%) and the test material was exposed to radiation from spent reactor fuel (instead of cobalt 60). The specimens were all slightly bleached at $1{\cdot}1 \times 10^7$ rads, and blackened at $1{\cdot}1 \times 10^8$ rads.

Each figure in the table below is the average from eight specimens.

GAMMA RADIATION DOSE	TENSILE PRODUCT*** TTP	TXP
none	5·7	5·9
$1{\cdot}1 \times 10^7$ rads	5·8	6·3
$1{\cdot}1 \times 10^8$ rads	4·9	4·6
s.s.d.**	0·7	0·7

*A condensed version of this report appeared in *Nuclear Technology* (NUCLEAR POWER Jan 59 p. 123).

**s.s.d.—The smallest significant difference calculated on 42 degrees of freedom, at the 95% level, is 0·7; any smaller difference could be due to experimental error.

***The tensile product is the product of the tensile strength and elongation of the specimen at breaking point, and is roughly proportional to the work done in rupturing it. It is a useful measure of the ' toughness ' of a material.

Large duct bellows readied for site

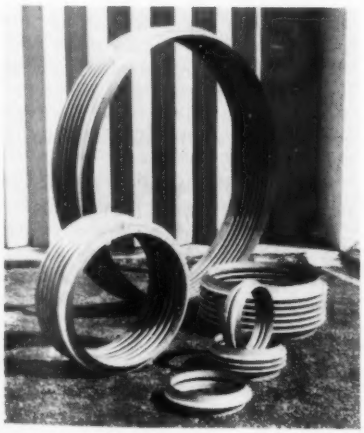
Development to meet all nuclear applications

Bellows and expansion joints

'IF IT IS A BELLOWS we can make it' covers the aims and activities of the Bellows Division of Teddington Aircraft Controls Ltd at Ammanford in Carmarthenshire. Now that the UKAEA has approved their design and fabrication methods for large diameter bellows in 18/8 Ti-stabilized stainless steel, this company can meet all expansion joint or bellow requirements in a nuclear power station such as is at present being built by the consortia. Units are supplied ranging in size from a nominal ½ in. bore to those which are large enough to allow a double-decker bus to be driven through them.

Originally the use of bellows was limited to instruments and subsequently for sealing the stems of special control valves. Some six years ago bellows began to be used for expansion joint duties in America and they were quickly taken up both here and on the Continent—the early work was limited to cold forming convolutions on thin-walled drawn tubing supplied by the tube manufacturers. Even at this stage Teddington decided to standardize on stainless steel bellows except for special applications. Normal tubing was suitable for units up to 3 in. dia but due to difficulties in drawing, an alternative method had to be found for larger sizes. After much research it was decided to butt weld sheet material under very carefully controlled conditions where the temperature is kept to a minimum consistent with good welding so as to prevent changing the characteristics of the parent metal. The welds are made so that they have the same thickness and working abilities as the sheet metal; from these fabricated tubes the bellows are made by either rolling or hydraulically pressing the convolutions. Right from the beginning the Works have maintained that the most efficient bellows are those made from thin-walled material.

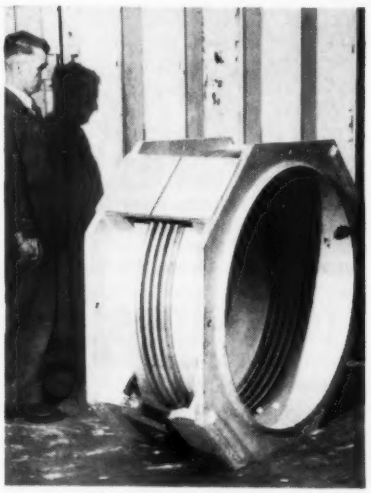
Deep convolution bellows of between 1 and 5 ft diameter fabricated in stainless steel



An early application of fabricated bellows made by these Works was for diesel exhaust tubes on naval MTBs where they were employed to ensure that toxic fumes were not freed in the engine room due to either the effect of rough seas or nearby blast shocks fracturing a stiff exhaust tube. These were followed by bellows for jet engine tail pipes where lightness combined with good heat resisting properties were required and the bellows had to deal with a very wide temperature range. Both these types proved to be good forerunners to meet nuclear requirements and at the present time Teddington bellows are employed extensively in both thermonuclear and fission reactors for a wide range of duties.

Bellows are used to allow for thermal expansion and contraction, vibration, movement and the stresses and strains arising in pipe layouts and associated equipment. Also they may be used to compensate expansion of a fluid or gas within a sealed chamber, transmitting a movement from within a sealed chamber and providing a packless gland shaft sealing.

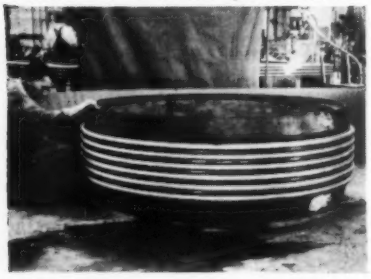
By far the most common application is that associated with pipe layouts and bellow expansion joints provide many advantages over the earlier types of expansion joints or loops. In the case of sliding joints, bellows eliminate possibilities of leaking and at the same time reduce the number of fittings required and loads on the pipes and their supports. By virtue of their flexibility the replacement of pipe loops by bellows reduces the loading on the pipelines and greater movement can be accommodated in less space. These units may be either single or double where in the latter the two bellows are separated by a short length of tubing. Standard single units are available in sizes from ½ in. nominal bore to 72 in. nominal bore. Stainless steel bellows are commonly used for temperatures up to between 600 and 700°C and Nimonic 75 for higher temperatures. Very small bellows, up to 1¼ in. bore can sustain high working pressures of 700 to 800 psi but with increasing diameters the maximum pressures tend to decrease. By special designing and the incor-



Hinge-restrained single unit made for an Italian works

Tie bars restrain pressure loads—single and double units

Ready for pressure testing—main duct bellows for a nuclear power station



poration of restraining rings to contain hoop stresses, pressures of up to 300 psi can be contained by bellows of 5 ft and 6 ft diameter.

As the pressure within a bellows acts on the mean effective area, any bending of the bellows will result in an uneven or shear loading and it is desirable to restrain these forces. This is done by restraining the bellows by means of tie-bars across the flanges which prevent either excessive expansion or contraction. Where angular movement is required, restraining can still be achieved by hinging the units on the relevant plane. It is common practice now to utilize three or four of these hinged units to replace the expansion loop and the end loads on the pipe line is very considerably reduced.

Bellows are made in the circular form with an argonarc-welded seam for all sizes from 3 in. up to 10 ft in diameter and in fact there is no real reason to prevent circular bellows being made to any size, the only limiting factor being the work hardening conditions of the material encountered when very large diameters have to be rolled. For very large bellows, anything up to 25 ft by 12 ft, special section sheet material is used which when welded together gives the convolution form required. These rectangular bellows are fabricated up with radiused corner pieces as tests have proved that square corners provide unnecessarily heavy load points. To fabricate a multi-unit bellows the sections are first spot welded together in pairs to give single convolutions and then fitted in a jig and the requisite number argonarc welded together. At present this type of bellows is used predominately on the ducts and flues of conventional coal-fired power stations but have possible nuclear applications in air locks.

Bellows are used in nuclear installations on all types of pipe lines as well as for special applications in thermonuclear work. The largest size being used in the nuclear power stations under construction are 6 ft 1 in. in diameter and in the 'double' form surround the main ducts where these pass through the biological shield while maintaining an air tight seal. They allow the duct to move a maximum of 3 in. in any direction relative to the shield. While 18/8 titanium-stabilized stainless steel is normally employed, bellows have also been made from chrome molybdenum steel, Monel, Inconel, the Nimonic series of alloys, Nilo K, titanium and other materials are being investigated for special applications. For overseas reactor projects where the authorities wish to fabricate as much equipment as possible within their own country the flanges and any other fittings are supplied and fitted by them onto the bellows made at Ammanford. It is anticipated that this course will be followed for the bellow units required for the proposed overseas nuclear power plant and will be similar in design to those in this country.

PROGRESS IN INDUSTRY

Transferring without leakage

Self-sealing couplings for liquids and gases

SELF-SEALING COUPLINGS and hose assemblies for nuclear applications are among the specialized products designed and manufactured by the Avery Division of Lockheed Precision Products Ltd at Speke, Liverpool. This company which came into existence at the beginning of this year is a subsidiary of Automotive Products Associated Ltd and is now responsible for the group's self-sealing couplings and hoses, oil and water hydraulic and pneumatic systems together with associated aircraft equipment. Research and development of equipment for nuclear power stations is being undertaken and facilities are available to investigate operating conditions. In this way their designers provide the most efficient and economical solution to any particular problem.

Some seven years ago Harwell had the first delivery of a number of self-sealing couplings which are continuing to give good service without, so far, any servicing. It is of interest to note that these couplings were of a design originally made to meet a requirement in connexion with Rolls-Royce jet engines. Since then this type of coupling has been increasingly used in all branches of nuclear engineering.

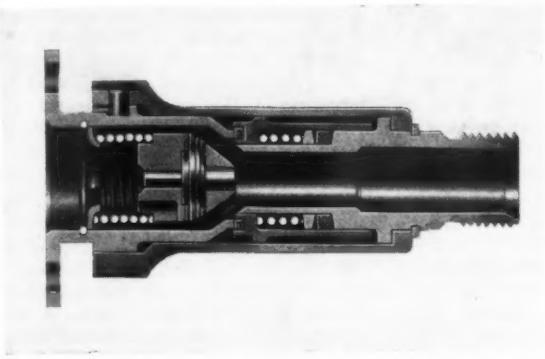
The couplings are basically of two types, screwed pressure replenishing connexions and bayonet operated units. Both these give a connexion which is automatically made without leakage and without any contained material remaining when disconnecting. These couplings afford hermetical sealing where any leaking is positively prevented and air or other foreign matter is excluded when the line is disconnected or re-connexion is made.

The replenishing connexions which were developed for pressurized fuelling systems enable a very high rate of flow to be safely used with the consequent saving in time for refuelling or transferring fluids in bulk. The connexion consists of two main components—the male flanged connector for fitting to a tank or static pipe line and the female coupling for attachment to the flexible pipe line which is provided with either a hand wheel or union nut. Each component contains its own sealing valve which is only opened when the two are screwed together. The relative positioning of the internal valves to the connecting portions ensures that there is no flow until the coupling is fully made; conversely the flow is completely cut off before the connexion can be broken. These actions are entirely automatic and no outside valve or control equipment is necessary.

A very wide range of liquids can be handled by these connexions including such difficult materials as liquefied petroleum gases. The normal handwheel operated types are available in 1½ and 2½ in. nominal bores

and are suitable for working pressures up to 50 psi while the union nut versions are made in 1¼ and 1½ in. nominal bore sizes and which will work with pressures up to 500 and 200 psi respectively.

The bayonet-type of self-sealing coupling is basically the same as the screwed replenishing connexions, consisting of a fixed and free or union component with variations in the type of seal according to operating conditions and the method of attaching the static portion to the pipe line, tank or surrounding structure. The standard range of these units is ¼, ⅜, ½ and ¾ in. nominal bore of which the ¼ in. size is suitable for a maximum pressure of 1500 psi.



Simplicity of design and effective sealing is the basis of bayonet type self-sealing couplings for high pressure lines

For installation where the couplings remain disconnected for any length of time the exposed surfaces of the two components can be protected with blanking caps.

As these couplings were originally designed for aircraft use the initial production was effected in duralumin with certain components in mild steel. As the range of materials handled was widened to include highly inflammable liquefied petroleum gases such as propane and butane, the material of the body of the fixed half coupling was changed to gun-metal and the connecting union nut of the union half of the coupling while being left free to rotate was retained by a circlip so that it could not be pushed back to expose the body or valve to external contact which might lead to accidental sparking.

To meet higher temperature requirements the mild steel and duralumin components are replaced by nimonic steels and have proved efficient at temperatures in the region of 150–180°C. The materials of the seals in the couplings are dependent upon the combined factors of the fluid to be handled and the operating temperature. Broadly speaking impregnated fabrics are used for liquids and straight natural or synthetic rubbers for gases. The synthetics employed include neoprene, PTFE, butyl and silicones of varying Shore hardnesses. By continued development certain of the bayonet type self-sealing couplings are suitable for working pressures of up to 4000 psi. All components are subject to AID standard of inspection and the finished coupling is tested under simulated operating and overload conditions. In the case of a 4000 psi working pressure unit the maximum test pressure is 6000 psi which in itself represents only half the design pressure—a fact which underlines the basic mechanical strength of these couplings.

Nuclear applications

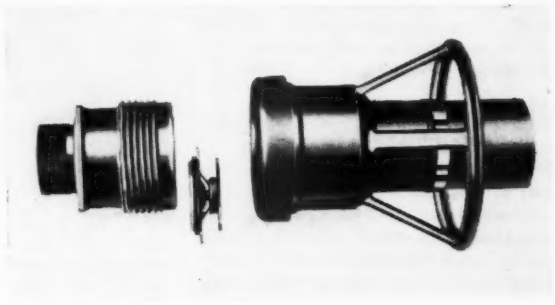
For these, stainless steel was introduced into the production—18/8/Ti stabilized and S.80 grades are predominantly used. In addition to the normal inspection already reviewed additional testing is carried out so that a coupling is checked against its particular application and complies with any special requirements stipulated by the AEA or other relevant authority and contractor. When couplings are produced for nuclear purposes the components are diverted from the main production line and subjected to a series of cleaning operations after which they are not handled with bare hands but inspected and packed in a clean area by operators wearing protective clothing and gloves.

These couplings are employed in a large number of applications within reactor buildings and are particularly useful in providing connecting points for filling, replenishing or emptying vessels of liquids or gases which are either toxic or radioactive and for sampling points along the various pipe circuits. In the case of the DIDO and PLUTO reactors at Harwell they are employed in the handling of heavy water, ½ and 1½ in. sizes at pressures between 10 and 50 psi and temperatures in the range of 60–66°C; heavy water and helium, 1 and 1½ in. sizes at 60 psi and 66°C; demineralized water on the shield cooling circuit, ¼, ⅜ and ½ in. sizes working at 40 psi and 46°C; air and carbon dioxide on the general reactor circuit 1½ and 2½ in. lines in the form of take-off points, ¼ in. size working at 13 psi and nitrogen, ½ in. size, at 60 psi and 66°C. Recently additional couplings have been incorporated on new cooling facilities in DIDO. These couplings are also employed on similar duties in the Australian HIFAR and the Danish DR3 materials testing reactors.

Following the applications in experimental reactors these couplings have been chosen for use in the nuclear power station programme. The English Electric-Babcock & Wilcox and the AEI-John Thompson groups are using these self-sealing couplings on the carbon dioxide lines. In the case of AEI-John Thompson's application it called for special development as the working temperature is in the region of 130°C.

At present couplings are being produced for use in connexion with the land-based submarine reactor at Dounreay capable of handling large quantities of helium. The 1¼ in. size has a flow of 0·245 lb/sec and the ⅝ in. size 0·0432 lb/sec of helium. To meet new high temperature requirements on carbon dioxide lines development is in hand to make a special self-sealing coupling capable of operating at 200°C.

The Avery Division supplies several different grades of synthetic tubing for use with their couplings and undertakes the complete design and manufacture to meet any requirements. In this way the company ensures that a balanced circuit is put into operation.



Hand-operated screwed pressure coupling used for replenishing and transfer duties

New Product Survey

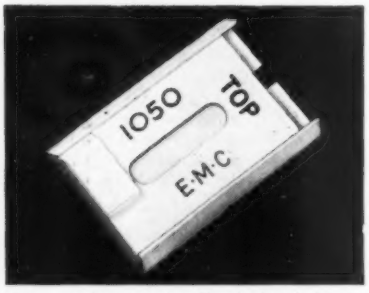
PLANT · EQUIPMENT · INSTRUMENTS · MATERIALS

FILM BADGES

new British service

Electronic Machine Co Ltd have now formed a Radiological Division which is offering a complete radiation monitoring service to users of X-ray machines and radioactive materials. Under contract, the service will supply a numbered film badge (designed by Dr G. Spiegler, formerly of the Royal Marsden Hospital), one spare film being supplied at the same time for replacement at the end of the first week.

At the end of each week the film is removed from the holder and posted for



The number on the film badge belongs to the individual and a complete record is obtained of his dosage history

processing, reading and recording, the spare film then being put into the holder. A further film replacement is sent by the service on receipt by them of the first film for processing.

In the event of a weekly or cumulative dose exceeding the recommended dosage, an immediate communication is sent to the Safety Officer or the Principal of the organization concerned so that immediate steps may be taken.

This Radiation Monitoring Division of Electronic Machine Co has a staff of trained personnel and an advisory panel of physicians and physicists available to investigate, on site, causes of excessive dosage and will advise on safety measures to be taken. The team is available also to advise on safety measures when new installations are being planned or installed and facilities are being arranged for urine analysis, blood counts and analysis of soil samples, food, etc.

Tick **No 208** on reply card

THERMOCOUPLE

nuclear applications

Developed by the Baker Platinum Division of Engelhard Industries Ltd as a high-temperature precious metal thermocouple assembly which is both flexible and of small diameter, the Baker Integral-sheath Thermocouple consists of an outer, flexible metallic sheath having an external diameter of approximately $\frac{1}{16}$ in. surrounding two wires comprising the thermoelements. These are insulated from one another and from the sheath by means of a compressed pure oxide refractory powder, and the resulting assembly is flexible enough to be formed round a diameter four times that of the assembly without damage. It has already found application in at least one type of high temperature nuclear test loop, where the requirements of flexibility and small dimensions precluded the use of conventional assemblies. A modified assembly of this type is already under development, and consists of an outer metallic sheath (which in addition forms one element of the couple) surrounding a centrally located single wire which forms the second element.

The twin-element wire type is currently available in several standard forms. One of them, the Type W 7/B, specially designed for nuclear work, has a sheath of Baker SP70 alloy, a positive element of Baker 43 alloy and a negative element of CP Platinum. It is suitable for use at temperatures up to 1600°C, in inert or reducing atmospheres only. The grain-stabilized sheath alloy and the thermoelement materials are resistant to irradiation.

Tick **No 209** on reply card

SCINTILLATION HEAD UNIT

novel light-lock

Nuclear Enterprises' new shielded scintillation head unit NE 5503 was displayed for the first time at the recent Physical Society Exhibition in London. It was shown as part of the efficient assembly for C-14 and tritium counting, the NE 8301, where it is used in conjunction with Nuclear Enterprises' non-overloading amplifier NE 5502 (gain 50,000), precision single channel pulse height selector NE 5102, and stabilized EHT supply NE 5302.

The scintillation head unit houses a 1 in. dia photomultiplier of very low noise level, along with a White cathode follower preamplifier of good signal/noise ratio, and a $1\frac{1}{2}$ in. lead shield

The new head unit features a special rotary light locking device which prevents light reaching the photomultiplier during the changing of samples. In order to do this, the sample cell is loaded in a chamber on the side of the castle and revolved in a simple two-movement operation into the counting position. This operation brings the counting cell in close contact with the photomultiplier. The coupling medium between the photomultiplier and the sample cell is silicone fluid MS 200 of low viscosity. The reason for the light locking device is that a photomultiplier which is not dark-adapted gives a background noise many times greater than it does after being kept in the dark for several days.

Tick **No 210** on reply card

HARDFACING

induction heating

A new process for hardfacing with 'Stellite' powder results from a collaboration between Deloro Stellite Ltd and Radio Heaters Ltd. The Radyne/Stellite technique, called the 'sprinkle fuse' process, is carried out in these stages: (1) the Stellite powder and flux are placed in the recess in the steel blank (2) the steel is positioned next to the work coil of the Radyne induction equipment (3) pushbutton heating is initiated with or without rotation of the parts (4) when the bonding temperature is reached throughout the Stellite layer and the recess, the heating is stopped automatically. Advantages are the elimination of welding skill and the introduction of automatic heat control which reduces heating times and economizes on hardfacing alloys, and the process should be helpful where resistance to abrasion, corrosion or heat is necessary e.g. in valve seatings, seat rings and disks, pump sealing rings and thrust plates.

Tick **No 211** on reply card

MULTIMETER

electronic model

An input impedance of up to 10^{14} ohms without the use of electrometer or vibrating capacitor circuits is claimed for Metrix Instruments' new ERIC Electronic Multimeter for voltage, current, resistance and other measurements. A symmetrical three-terminal circuit using conventional valves is employed and the output impedance is exceptionally low. It feeds an amplifier and meter with the facility for connecting an external re-

Measurements which either require elaborate and costly equipment or which cannot be made with instruments of conventional design are possible on this new Metrix multimeter

corder. The circuit design is such that an unusual degree of stability is achieved and when a voltage is applied in the 'memory' position (a polystyrene capacitor is switched across the input circuit) the instrument retains the reading for at least twelve hours after disconnecting the source with less than 1% drift.

Small voltage variations can be made with full-scale discrimination regardless of absolute value using an external capacitor with guard-ring. The capacitor is connected in series with the source and is first charged to the source voltage by short-circuiting the input to the instrument. When the short-circuit is removed the voltage across the instrument is initially zero and records only variations of the source voltage. By using a constant voltage source, the hysteresis losses of capacitors can be measured in a similar manner. Basic ranges of the instrument are: 0·05 V–2 kV, $0{\cdot}5 \times 10^{-7}$–2×10^{-3} amps, 1–2×10^{10} ohms. A range of adaptors extends the range to 35 kV, $0{\cdot}5 \times 10^{-10}$ amps, 10^{13} ohms. Other accessories include V.H.F. probe, analogue integration adaptor, Coulomb-meter adaptor, and pH meter attachment.

Tick **No 212** on reply card

SAMPLE CHANGING

new automatic type

Capacities of up to 1000 planchets with diameters of 5 in. or greater are achieved with a new type of loading and unloading mechanism developed by the Nucleonic Corporation of America for automatic sample changes. Any nuclear counting can be handled, and the SC Automatic Sample Changer should be useful outside as well as inside the laboratory, for instance in counting airborne radioactive particles collected on large filter paper disks to give continuous monitoring in and around nuclear installations. The counting system can handle a work load equivalent to that handled by ten technicians counting continuously say the Corporation. Other features that can be provided are two or more detector heads permitting separate measurements of alpha, beta, and gamma radiation from the sample; direct print-out of sample number and counts/minute to a preset time, or sample number and time to a preset counts/minute can also be supplied for each type of radiation.

Tick **No 213** on reply card

VOLTMETER

Ferranti digital instrument

A digital voltmeter is now in quantity production by Ferranti Ltd. The three digit model D101 covers the range of 0·01 V to 999 V d.c. with automatic ranging, polarity and decimal placement and with the accuracy of 0·1% on any of the three ranges, which are 0·01 to 9·99, 10·0 to 99·9, and 100 to 999 V d.c. The average reading time is 0·7 seconds.

In operation, the input voltage is compared to the voltage from a Kelvin-Varley potentiometer and any difference actuates stepping switches until a balance is achieved, enabling the measured voltage to be presented digitally in the form of ¾ in. high illuminated numerals in a 1¼ by 5¼ in. display area. The reference voltage is from a bank of mercury cells. Stability is achieved by the use of a transistorized amplifier and high grade choppers, the accuracy of the instrument being unaffected by mains variation. Printed circuitry has been extensively used to ensure reliability. Facilities for printout and remote readout are included.

Tick **No 214** on reply card

AUTOMATIC WEIGHING

programming system

The weight of materials to be discharged from storage bins or hoppers can be set-up on dials or programmed on punched cards or tape with the EMI *Emiway* control system, which can be fitted to most types of scale. Automatic switching from fast to slow feed is provided, and the system ensures accuracies in the region of 1 part in 1000 of the 360° of a scale dial movement. When required, remote indicators can be provided enabling the weight on the scale dial to be displayed simultaneously at any number of other points. Data such as time, date, type of material, source, destination and costs can be recorded automatically for stock control and accounting purposes, by electric typewriter or teleprinter, card or tape punch.

The basic equipment consists of 5 units: (1) The scale transducer (2) analogue to digital conversion unit (3) print out decimal to binary conversion and control unit (4) power units (5) remote display. A transducer is fitted on the back of the scale which is coupled directly to the pointer shaft. Remote from the scale, in any convenient location is the main cabinet, including the servo equipment, digitizer (which converts the shaft angle to an unambiguous digital code representing the angular displacement) and other units. Decoding of this digital information is performed by an electric decoder, which works at very high speed and unlike the relay type of decoder, can accurately follow the rapidly varying movement of a scale pointer in either direction. The output may be continuously displayed, and by means of coincidence circuits, the decimal output from the decoder can be 'caught' at a predetermined setting, and made to control, say, the feeding mechanism of the material being weighed. An unlimited number of such circuits can be added and set as required to perform a number of different functions at different weights (e.g. coarse and fine feeding, of several different materials on a cumulative weighing system). A delay network may be added which assures that the scale has come to rest before further action, such as print-out or adding another ingredient to the weight, takes place. In the print-out equipment, the decimal outputs are scanned, in sequence, the scanning system stopping momentarily on each digit to be printed, allowing sufficient time for a teleprinter to print that figure, before searching for the next digit.

Tick **No 215** on reply card

N-D TESTING

tube fault locator

A tube tester design by CNS Instruments Ltd for rapid location of faults in tubes of non-ferrous metal or stainless steel and for locating corrosion of condenser tubes in steam boiler installations is so laid out that the testing can be carried out by untrained personnel once the initial setting has been made by the supervisor. The equipment consists of a probe or probes containing search coils which are passed around or through the tube specimen. The proximity of the metal

The CNS tester for non-magnetic tubes is capable of probe speeds of up to 100 ft per minute

causes resistive and inductive changes in the coil characteristics which remain constant as long as the tube metal is consistently homogeneous and free from faults. The probe coils are balanced to give a zero on a meter by resistive and inductive variables inside the main unit. The coils are balanced in a good speci-

men of the material or in a known good section of the tube itself. The testing is carried out by sliding the probe along the tube and as each fault is scanned by the probe the meter zero balance is upset and an indication is given on a meter needle, a warning light and by the ringing of a buzzer alarm. With a high speed alarm relay testing can proceed at 100 feet per minute. The alarm system is adjustable in sensitivity so that the user can pass over very small faults and reject only where the faults are of significant size. In practice it has been found that cracks equal in size to 5% of the tube wall thickness are easily detectable and a 2½% step in wall thickness gives a pronounced signal.

When the equipment is used for checking for corrosion in condenser tubes, the probe is first set to balance in a well known good specimen of the original material. This balance is set by variable resistance and inductance within the unit and upon probing the condenser tubes any corrosion will instantly produce an out of balance effect which will sound the alarm. A known standard specimen is necessary where there is corrosion which may be equal in extent throughout the length of the tube. To take care of differing resistivity and permeability the instrument has a frequency switch giving four ranges which are sufficient to cover all materials in normal use.

Tick **No 216** on reply card

DOSIMETRY

new personal meter

A pocket dosimeter of the fountain-pen type known as the *Condiognom* eliminates interference with the readings on the part of the wearer as he is unable to take a direct reading of the dose. The reading is done at a central point by means of a mains-operated charging and measuring device which is suitable for use with any number of dosimeter chambers.

The *Condiognom* has two (twin) condenser chambers which are screwed together; they are provided with a clip and are not separated except for charging and measuring. Each chamber with its amber insulated electrode is hermetically sealed and operates independently. The measuring range of the larger chamber is 0–100 mR and thus adequately covers the maximum permissible daily dose for personnel engaged in radioactive work. The smaller chamber covers 0–1000 mR and is designed to register any quantities received when the larger chamber is completely discharged.

The chambers are charged separately before being issued; ionizing radiation partially discharges each chamber and the loss of charge is determined by measuring the chamber voltage electrostatically. The meter indicates directly in

Unlike other fountain pen dosimeters, the Condiognom is read by plugging into a combined charging and measuring unit

milliroentgens. Air wall materials are used in the chambers and the readings are therefore practically independent of radiation energy from 50 keV to gamma rays of cobalt and radium. The instrument is produced by Radiatron.

Tick **No 217** on reply card

IN BRIEF

Motors Newman Industries have introduced a range of totally enclosed motors, ¾ to 2 hp, in '66' frame dimensions (BS 2048 and NEMA Standard MG.1) to bridge the gap, practically and economically, which usually exists between fractional horsepower motors and the smallest of the industrial type motors. They are available for single-phase (capacitor start, ¾-1½ hp) or three-phase (1-2 hp) operation and can be supplied for foot, flange or foot and flange mounting. 1500 rpm (50 cycles) and 1800 rpm (60 cycles) are the first speeds to be introduced but other speeds will be incorporated later.

Tick **No 218** on reply card

Automatic levels Cooke, Troughton & Simms and Hilger & Watts announce joint development of an optical stabilizer which can be incorporated in the telescope of a surveyor's level in order to effect automatic compensation for any small errors in levelling. The method of compensation does not depend upon any need to magnify mechanically the residual tilt of the instrument, but obtains the equivalent correction by purely optical means, and this has advantages over methods recently developed on the Continent.

Tick **No 219** on reply card

Relays The Series 593 Relay (Magnetic Devices Ltd) is an interlocking unit designed for switching between alternate circuits at regular or irregular intervals. It is suitable for applications such as flow-control motors, positioning devices and sorting mechanisms and consists of a pair of relays that are mutually interlocking so that one or the other is always locked in. Either or both coils can be supplied for a.c. or d.c. operation and either or both relays may carry multiple contact assemblies.

Tick **No 220** on reply card

Digital indicator The Aircraft Components and Connector Division of Thorn Electrical Industries Ltd have introduced an Edge-Lit Indicator, only 1⅛ in. deep × 4¼ in. long × 1⅛ in. wide, for use with digital computers. A high level of illumination is ensured by the incorporation of Atlas Midget Panel Lamps as the light source and the depth of the unit is only 1⅛ in. from front to back.

Tick **No 221** on reply card

Protective atmosphere generator Used for preventing unwanted chemical change at the surface of metals during heat treatment, a small exothermic gas generator produced by Royce Electric Furnaces Ltd has a rated output of 150 cu ft per hour. Floor area is less than 9 sq ft. The prepared atmosphere is obtained by controlled combustion of town gas.

Tick **No 222** on reply card

Polyurethane rubber Precision Rubbers Ltd have developed an improved processing technique that makes their *Prescollan* suitable for O-ring seals, bellows, guide bushes, hydraulic and pneumatic seals, diaphragms and valve seats.

Tick **No 223** on reply card

Effluent monitor Tracerlab have brought out a new retention tank and water monitor for water-cooled reactors. Autocontrols route effluent to retention tank or disposal channel depending on preset tolerance limits.

Tick **No 224** on reply card

Vacuum pumps Three new *Speedivac* models from Edwards High Vacuum—1SC900, 1SC1500 and 1SC3000. The first is a rotary vane model; the others, rotary piston. All are single-stage with ultimate of 0·01 mm. without gas ballast.

Tick **No 225** on reply card

Welding transformers Philips Electrical have introduced three new models: ES1370—65 A for 14 s.w.g. electrodes; ES1371—for general purposes; ES1372—for heavy duty.

Tick **No 226** on reply card

High accuracy bridges Impedance comparison bridges developed by Wayne Kerr are claimed to have an accuracy of 0·001% in both megohm and thousand ohm ranges.

Tick **No 227** on reply card

Sub-sub-miniature By Honeywell, the type SX switch is 0·5 × 0·35 × 0·2 in., weighs 1/28 oz. Single-pole, double-throw it's available with plunger, roller or lever actuator.

Tick **No 228** on reply card

INDUSTRIAL NEWSDESK

Industry not waiting

Encouraged by Lloyds, British shipbuilders and marine engineers are preparing to meet the challenge of US and Continental plans for nuclear-powered merchant ships. The Government is aware of the position but at the moment will not commit itself and it is not expected that any recommendations will be made until after the next meeting of the Galbraith Committee. Named after the Civil Lord of the Admiralty, this committee consists of naval, atomic, shipping and shipbuilding experts and technicians and is itself awaiting a report from the AEA on the potentialities of their advanced gas-cooled reactor; so it will be May at least before the official view is made known.

In the meantime industry goes ahead. Yarrow & Co Ltd of Glasgow has spent nearly £M1 on modernization of plant and facilities and is devoting half of its research department's staff to investigating the application of nuclear power for ship propulsion.

Vickers Nuclear Engineering Ltd with their associates have so far made studies of a D_2O moderated steam-cooled reactor and a graphite-moderated gas-cooled reactor for marine use.

Vickers-Armstrongs (Engineers) Ltd have prepared designs for fuel charging and discharging equipment including those for a 20,000 dwt tanker as well as designing and building the associated lead coffins. This company has for some time been investigating the problem of marine nuclear propulsion and its studies have covered a whole range of deadweight capacities up to 100,000 tons. The investigation included the installation of a gas-cooled carbon-moderated reactor in a tanker of 65,000 tons dwt. At present further studies are being made into other types of nuclear propulsion systems in their search for the most economic power plant.

The David Brown Jackson Division of Salford, one of the David Brown Group of companies, is negotiating the manufacturing rights of a patent form of shielding developed by Knapp Mills Inc, of New York. The Knapp Mills company has been the consultant of the Bureau of Ships of the US Navy on such items as shielding and equipment and have carried out work in conjunction with the first US nuclear-powered aircraft carrier and the first nuclear merchant ship.

While it is doubtful if an economic or nearly economic unit can be built in the near future Lloyd's have stressed that the lack of actual operating experience of a reactor under marine conditions may seriously handicap future commercial development. British aims should therefore be directed to building and launching a unit which is at least cheaper and more efficient than the overseas projects now in hand. There are already indications that UK companies are taking steps to group themselves so as to be better placed to realize these aims.

Getting the best of two worlds

A contract to develop a new type of uranium-based fuel has been awarded by the AEC to Nuclear Materials and Equipment Corp (NUMEC). This material is designed to overcome the difficulties of swelling and growth experienced with uranium metal fuel and the lower density and less efficient heat transfer characteristics of non-metallic uranium compounds. The new fuel is anticipated to combine the advantages of both uranium and uranium oxides without the disadvantages peculiar to either for both commercial and military uses.

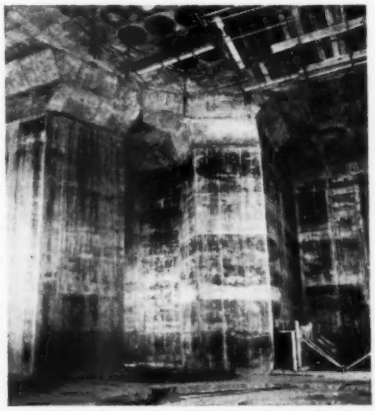
Other work by NUMEC utilizing uranium oxides includes the production of 120,000 uranium dioxide fuel pellets for the Sylvania-Corning Nuclear Corp who will pack them into rods for use in the 62 MW Controlled Recirculating Boiling Water Reactor (CRBR) at Sioux Falls (contractor: Allis-Chalmers); the production of special nuclear fuel materials enriched to 7% in the fissionable isotope U-235 for Atomic Energy of Canada.

Trouble in Scotland

The Hunterston nuclear power plant continues to grow but the civil engineering is proceeding much more rapidly and smoothly than the mechanical engineering—especially the fabrication of the reactor itself and the steam-raising plant. Civilly, the first reactor has reached an advanced stage and rapid progress is being made with the civil engineering work on the second reactor, the turbine hall and the extensive circulating-water system together with the starting of the construction of several ancillary buildings.

The pouring of the specially heavy concrete for the bottom shield around the complex stand-pipe sleeves structure was simplified by the prior use of mock-ups. These were employed to find the best method of pouring to ensure homogeneity of the concrete and so that a minimum density of 210 lb/cu ft would be maintained. The proof of the efficiency of this trial work was that the shield of nearly 400 cu yd was successfully cast in a continuous process taking only 39 hours. The top shield is partially formed of concrete beams, the largest of which weighs 308 tons; by pre-casting these beams much time will be saved in completing this top biological shield.

On the mechanical side progress has been made but labour disagreements and the necessity to 'cut out and reweld' on rather a large scale has slowed the work down. Strikes, although almost forming a regular part of normal working conditions, have been particularly heavy, averaging one a fortnight, with the result that this side of the project is lagging several months behind schedule. On March 12 a meeting between the management of the Motherwell Bridge and Engineering Co Ltd, the company concerned, and shop stewards has resulted in the formation of a joint production committee being set up and plans for the procedure for dealing with any future disputes. It is trusted that



The fuelling chamber below the bottom shield with the sleeves through which the standpipes will pass

HUNTERSTON : from below

By using special techniques, concrete was poured round these sleeves in only 39 hours

this will now enable the work valued at some £M8 to proceed more rapidly.

Computer movements

A new computer to the UK shown in London recently on its way from California to Germany was a Series 1100 Beckman/Berkeley EASE analogue computer. According to F. Winston Reynolds whose firm, Winston Electronics, are handling the machine in this country, some 20 have already been sold in the US and Europe. The computer is designed with a high degree of flexibility and includes a removable A-MF patchboard. An illustration of this machine appears on page 124 of this issue.

A Ferranti high-speed Mercury computer valued at about £150,000 has been sold to the University of Buenos Aires for nuclear research work. This is the seventeenth Mercury sold, of which 9 are used primarily for atomic research applications.

Nuclear fuel element calculations will be carried out by the Central Electricity Generating Board on the International Computers and Tabulators Ltd's Type 555 electronic calculator they are renting for their London Headquarters.

To further the use of computers Ferranti Ltd held an 'owners and users' conference in London on February 18 and 19. Among the 54 delegates attending there were representatives from the Belgian, French, Norwegian and Swedish nuclear research centres and the European Organization for Nuclear Research as well as the AEA, UK Universities and UK nuclear power plant constructors.

Essex station grows

Both the civil and mechanical engineering is proceeding well at Bradwell and with all the cladding and glazing completed the turbine house externally can be regarded as a finished structure. All six boilers for the No. 1 reactor have been installed and tubing-up is now in progress. The thermal dome for the No. 1 reactor has been completed and is ready for installation while the No. 2 reactor's thermal dome is nearing completion and work is in hand on the No. 1 reactor's fuelling machine.

AEA contracts placed

Further contracts have been placed in connexion with the Atomic Energy Establishment, Winfrith Heath. These are for the effluent pipeline from the site into the sea at Arish Mell. The first four miles overland is being constructed by Constructors John Brown Ltd; Taylor Woodrow Construction Ltd in association with Collins Submarine Pipelines Ltd have been awarded the contract for the remaining one mile of overland pipeline and the two miles of undersea section. Work on the sea section will begin at the end of March and will be completed by the end of September.

The Industrial Group of AEA have placed a contract with John Brown & Co Ltd for the fuelling machine for the advanced gas-cooled reactor at Windscale; the machine will be built by the company's special Engineering and Nuclear Division.

Independent research and design

A step to train design engineers independently of either the AEA or the private consortia has been taken by the Central Electricity Generating Board by the setting-up of its own research centre adjacent to the Berkeley nuclear power station. The establishment, estimated to cost about £M1, will consist of engineering, physics, metallurgy and chemistry laboratories and studies will be carried out on both intensely radioactive materials and non-active materials that give rise to toxic hazards.

A staff of some 150-200 scientists, technologists, skilled and unskilled tradesmen will staff the establishment and by a system of scholarships students from universities in the West of England and South Wales will be encouraged to join the staff. Among the functions of the laboratories will be a constant appraisal of the state of materials used in the construction of the reactors by detailed examination of monitor samples removed on a programmed basis from the Board's operating reactors and graphite behaviour programmes. Parallel with these the physicists and instrument engineers will aim to devise nucleonic instruments for use both in the laboratories and for reactor operation. In this way the work of the establishment will be directed to providing the Board's design engineers with better materials for improved and advanced designs.

The nearness of the Berkeley nuclear power station will greatly facilitate the supply of irradiated materials and samples but the research centre will be self-contained and administratively divorced from the power station.

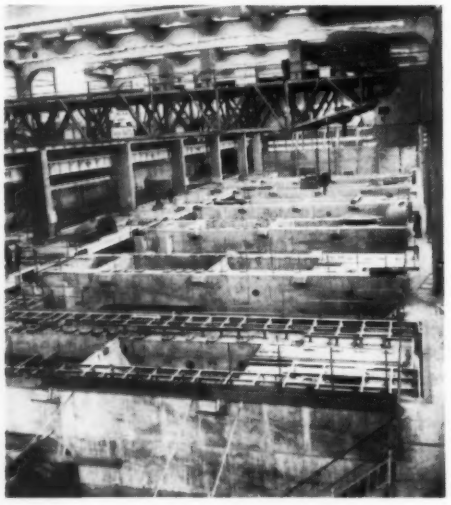
Robots do the work

A fleet of six robot units developed by The Babcock & Wilcox Company's Atomic Energy division are to be used in the Engineering Prototype Development Facility at Lynchburg, Va. They are independently and remotely controlled by radio from a master control console and from which either by television or directly through a 4 ft thick lead glass window observation may be kept on the radioactive work area. The fleet consists of a large three-ton fork-lift truck equipped with three mechanical arms, one of which duplicates wrist and arm functions and the other two can lift anything from a small spanner to a half-ton fitting; a trailer; a pipe-welder completed with an inspection 'eye'; a pipe-cutter and a 50-ton 'flying rope' crane with the driving mechanism located in an accessible position behind the crane's radiation shield. Remote control points for this robot maintenance force are provided and are manned by two technicians feeding push-button messages into an electronic grid complex. The grid in turn transmits the coded commands ultrasonically to the robots.

GEC developments

The Atomic Energy Division of GEC is now in a position to offer proposals for nuclear power stations having electrical outputs ranging from 40 to 400 MW per reactor. The production of these new designs for gas-cooled graphite-moderated reactors is the result of in-

Inside the turbine house, foundations and lifting gear are ready to receive the plant

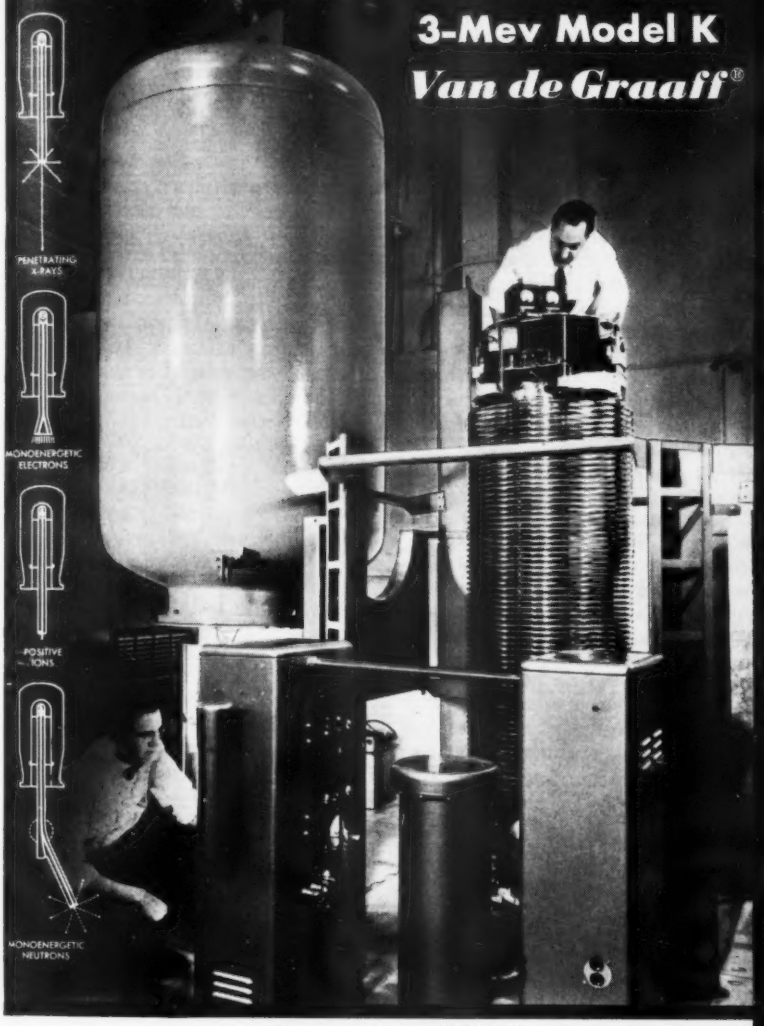


BRADWELL : from above

Interior of No 1 reactor with supports for the reactor and shell and with the main gas ducts projected through the walls

Versatile Research Accelerator

3-Mev Model K *Van de Graaff*®



Photos Courtesy of Gulf Research and Development Company

This powerful multi-particle accelerator — proved in the field — is the basic tool for a broad program of fundamental or applied radiation research.

Now in use for:

- Nuclear physics
- Radiation processing
- Polymerization
- Radiation chemistry
- Reactor engineering
- Sterilization
- Radiation damage
- Biology
- Particle injection
- Radiography

Visit the
HIGH VOLTAGE
Electron Processing
Exhibit
Stand 334
at the
International Plastics
Exhibition
17-27 June 1959
National Hall
Olympia - London,
England

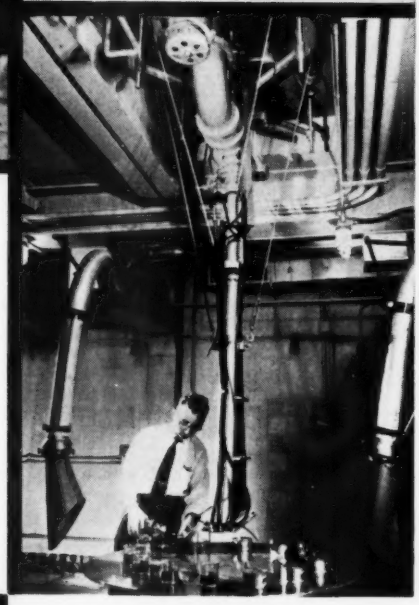
ELECTRONS:
1 microampere to 1 milliampere. (Use of maximum current requires beam scanning).

X-RAYS:
900 R per minute at one meter. (Equivalent to 20,000 curies of Cobalt-60).

POSITIVE IONS:
10 to 200 microamperes.

NEUTRONS:
6×10^{11} neutrons per second.

Both voltage and current output are stable, precisely controlled, and continuously variable.



HIGH VOLTAGE ENGINEERING
CORPORATION
BURLINGTON MASSACHUSETTS

HIGH VOLTAGE SERVICING CO., LTD.
60 Carpenters Wood Drive
Chorley Wood, Herts, England
Telephone Field End 7431

Tick **No 81** on reply card for further details

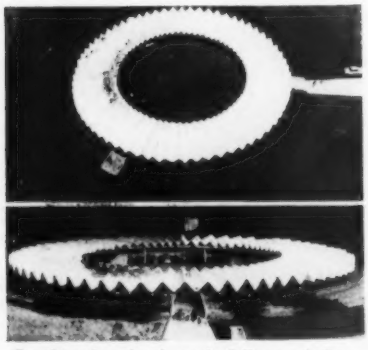
tensive research and development following the experience gained by the designing of the Hunterston nuclear power station and the Zenith high-temperature gas-cooled zero energy reactor for Winfrith Heath. A number of detailed tenders have been requested from and submitted to European and Far Eastern countries and several are at present under active consideration.

Detailed mechanical engineering research is being directed by GEC towards the development of sealed roller bearings, tests on various types of dry-running gears and semi-automatic welding processes. With the advent of higher reactor temperatures new types of fuel elements are being investigated.

Mainly education

● **Practising Internationals.** From 54 scientists and engineers 20 countries were represented at the Eighth Session of the International School of Nuclear and Engineering at the Argonne National Laboratory during this Spring. In addition to the US, Burma, Greece, India, Indonesia, Israel, Thailand and Venezuela were among the countries participating.

● **Florida gets licence.** AEC proposes issuing an operating licence to the University of Florida at Gainesville for their 10 kW (thermal) teaching reactor. It is a graphite moderated and reflected light-water cooled unit and uses 20% enriched fuel contained in flat plates clad with aluminium. The reactor will be installed in a building of monolithic concrete walls as a precast, lightweight, concrete roof deck sealed with tarred felt with a slag covering. This is the first reactor to go into operation in the State of Florida.



Combined school and fallout shelter designed for the Northern Californian section of American Institute of Architects

● **Nuclear Reactor Technology.** The Electrical Engineering and Physics departments of the Bradford Institute of Technology in association with the Harwell Reactor School of AEA are holding a six weeks' course starting April 20. This course is self-contained and will cover in detail the basic principles of the physics and engineering of nuclear power reactors and will include laboratory work as well as lectures, films and outside visits. Application forms and further information may be obtained from The Registrar, Bradford Institute of Technology, Bradford 7.

● **DIC in Nuclear Technology.** The first post-graduate course in nuclear technology (chemical) at the Imperial College has been announced and satisfactory completion of it will qualify for the award of Diploma of Imperial College (DIC). This course is also acceptable to the Department of Scientific and Industrial Research for the tenure of Advanced Course Studentships. The programme interprets nuclear technology in a wide sense and in addition to nuclear power production topics cover the applications of radioisotopes and the possible uses of sources of radiation for inducing industrial-scale chemical reactions. Applications should be made not later than June 1 to The Registrar, Imperial College, London, SW7.

● **Geneva films available.** AEC have made available for sale or on loan 45 technical-level 16mm films which were first shown at Geneva last September. Most are in colour and include 10 on power reactors, 9 on research and test reactors, 3 on reactor safety and 7 on fuels and their processing.

● **Process instrumentation.** A joint symposium on Instrumentation and Computation in Process Development and Plant Design is to be held at the Central Hall, Westminster, SW1, between May 11 and 13. It is organized by the Institution of Chemical Engineers, the Society of Instrument Technology and the British Computer Society. Among the papers to be read deuterium processing and nuclear furnace protection processing are included. Registrations should be addressed to the Institution of Chemical Engineers.

● **Radiation at health talks.** At the Royal Society of Health's Congress to be held at Harrogate between April 27 and May 1 an entirely new section devoted to radiation is to be introduced. It will be presided over by Sir Ernest Rock Carling, formerly Chairman of the International Commission on Radiological Protection.

● **Pye comes to town.** The Pye Argon Chromatograph will be the subject of lectures and demonstrations at the Northern Polytechnic, Holloway Road, London, N7, on April 8 and 9. Admission is by ticket only and applications should be made to W. G. Pye & Co Ltd, Granta Works, Cambridge.

● **School for service.** The Electroflo Service Training School has planned six courses for the first half of 1959. These fortnightly courses cover typical industrial instruments for the measurement and control of process variables with particular emphasis upon maintenance. This school is run by Electroflo Meters Co Ltd, of Abbey Rd, London, NW10.

● **Overseas activities.** When the students of the Harwell Reactor School recently visited the Hawker Siddeley Nuclear Power Co Ltd they had the opportunity of examining the 600 psi fuel element gas heat transfer rig being operated under contract to A/B Atomenergi of Stockholm.

● **Research and engineering.** Rochester, NY, University's new College of Engineering plans to expand its research, service and teaching programmes. Dr John W. Graham Jr will take up his appointment as the first Dean on July 1 to initiate these plans.

● **BNEC Conference.** A two-day meeting is to be held in London on April 29-30 on the progress of thermonuclear power research. It is sponsored by the British Nuclear Energy Conference and will be opened by Sir John Cockcroft. It will review not only UK work in this field but also US and Russian activities.

● **Professor Th. Reis** director of the French nuclear organization SATNUC of Paris has been conducting a course of lectures at the Spanish Escuela Tecnica Superior de Ingenieros Industriales in Barcelona. The course spread over February and March included reviews of the various types of reactors, health safeguards, radiation protection and neutron detection techniques.

● **A symposium** on the safety and location of nuclear plants is to be held in Rome between June 16 and 19 and is sponsored by the Comitato Nazionale per le Ricerche Nucleari. The programme includes environmental factors, intrinsic safety of nuclear plants, health engineering and financial implications of liability for possible accidents.

In brief

● **Vitro activities.** The Vitro Corp of America has taken over the Crane Co's of Chicago in the Heavy Minerals Co. This company located at Chattanooga is engaged in the production of rare earth chemicals, thorium and heavy minerals; it is an important supplier of rutile and ilmenite for the titanium industry. Following this take-over Berkshire Chemicals Inc have been made the exclusive sales agents for the products of Heavy Minerals.

● **Hot-cold-light panels.** Westinghouse Electric Corp have made the first experimental model of a three-purpose panel which provides illumination and heating or cooling facilities. This single operating unit combines two major technical advances—thermoelectric refrigeration and electroluminescent lighting.

● **More uranium.** AEC has amended its contract with Western Nuclear Corp to increase its process milling capacity from 400 tons to over 800 tons per day and

nucleol

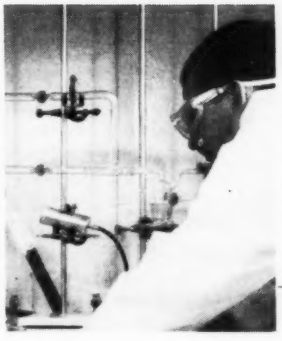
radiation resistant lubricants for the atomic age

A range developed and perfected by Wakefield-Dick Research

Conventional oils cannot live in conditions of atomic radiation. Such conditions are inseparable from certain parts of any mechanism designed to produce power from nuclear fission.

This, and other allied lubrication problems, was the challenge which faced oil technologists everywhere. And, as so often in the past, Wakefield-Dick's research team produced the answer. An entirely new series of oils and greases, resistant to radiation and named "Nucleol", is now available to lubricate the wheels of this Atomic Age.

INDUSTRIAL WAKEFIELD-DICK LUBRICANTS

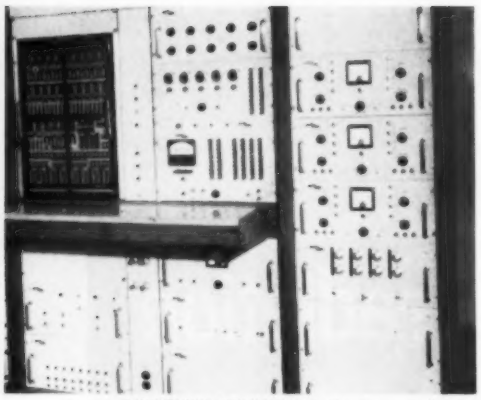


A Wakefield-Dick research chemist investigating the effects of radiation on lubricants.

Two examples of the NUCLEOL range

NUCLEOL 522 A radiation resistant lubricant based on selected mineral oils of high aromaticity and containing special inhibitors.

NUCLEOL G 114 A grease gelled with a new compound, and specially inhibited. Designed for the lubrication of control actuator bearings operating at the lower radiation levels.



LONDON STOPOVER On its way from California to Germany—a Beckman/Berkeley 1100 computer. Story on page 120

extend the termination date from March 31, 1962 to December 31, 1966.

● **Extra krypton-85.** Due to increased industrial applications especially in thickness gauges and self-luminous markers AEC is making up to 100,000 curies of krypton-85 available per annum for civilian uses.

INDUSTRIAL NEWSDESK

● **Computers uprate diesel engines.** Experimental work directed by computer calculations was employed in the design of the new range of Ruston & Hornsby AT diesel engines of 700–1645 bhp for generating duties on sites and marine applications.

● **Cheaper PTFE.** Due to lower raw material costs and improved production methods Permali Ltd have been able to reduce the price of their Permaflon PTFE by approximately 10%.

● **The Tandem Accelerator.** High Voltage Engineering Corp has completed this unit valued at $M1 which consists of two Van de Graaff accelerators in a pressure tank holding nitrogen at 225 psi for electrical insulation. The accelerator, for Atomic Energy of Canada, went into operation at Chalk River last month.

To further sales of their accelerators High Voltage are establishing a manufacturing plant for the European Common Market at Amersfoort in Holland and which will provide additional services to over 30 present installations in nine European countries, the Near East and Africa.

● **Easier arc-welding.** The Rubery Owen Group has formed the RowenArc Division to manufacture under licence in the UK the new West-Ing-Arc developed by the Westinghouse Electric Corp of Buffalo, NY. This system reduces the difficulties of arc-welding by using carbon dioxide and argon gases in place of solid flux.

● **Nuclear grade beryllium.** The Imperial Smelting Corp is installing plant at Avonmouth for the commercial production of nuclear grade beryllium metal and the first stage for limited quantities will be in operation by the end of this year.

● **Electro-slag welding.** The O.K. Organization are to manufacture equipment for the Russian process which completely eliminates the arc. Two sizes of machine are foreseen—one for materials 2½ to 24 in. thick; the other for 1¼ to 4 in.

NAMES IN THE NEWS

The Earl of Halsbury who relinquishes his post as managing director of the National Research Development Corporation this month is to join the board of Lancashire Dynamo Holdings as vice-chairman. **Mr J. C. Duckworth,** chief

LORD HALSBURY

J. C. DUCKWORTH

CEGB will succeed Lord Halsbury on the NRDC. Mr Duckworth was closely connected with the early days of atomic energy both at Harwell and Chalk River, Canada.

Midland Silicones Ltd announce the appointment of **Mr C. B. Evans** to their board. Mr Evans joined the company in 1955 as works manager of the company's plant at Barry, near Cardiff.

Mr J. G. Marsden has joined Anti-dust Services Ltd as general sales manager.

New managing director at Mancuna Engineering Ltd is **Mr R. A. Le Page.**

During a recent visit to Los Angeles **Mr E. M. Price,** general manager of English Electric's atomic division called on Dr Chauncey Starr, general manager of Atomics International at Canoga Park.

Mr J. R. Hughes has been appointed a director and commercial manager of Hivac Ltd.

Mr P. Alsop has joined Technograph Electronic Products to be responsible for the technical sales division in the fields of computer, guided weapons and airborne equipment. He was previously with EMI Electronics.

The newly established Chair of Nuclear Science and Technology at the Royal Naval College, Greenwich, will have as its first professor **Mr J. Edwards,** who was formerly senior principal scientific officer in the Royal Naval Scientific Service in charge of Harwell's naval section. Mr Edwards was particularly concerned with work on the *Dreadnought* project.

America's Atomic Energy Commission have appointed **W. S. Hutchinson** as director of the source material procurement division of the Grand Junction Operations Office.

Mr H. G. Stage and **Mr F. Tompkins** have been made directors of Nu-Swift Ltd.

Mr C. S. Youatt has relinquished his position as deputy chairman of Rhodes, Brydon & Youatt but remains a director. New deputy chairman will be **Mr A. H. Parkes. Mr H. Aston** was elected a director of the board.

G. & J. Weir Holdings Ltd announce the appointment of **Mr I. M. Stewart,** and **Mr J. H. Lord** to their board.

CEGB appointments. **Mr R. D. Gardiner** formerly of the AEA's Industrial Group has joined the CEGB as assistant chief contracts officer. **Mr S. Swallow** has been appointed assistant chief purchasing officer.

Dr Marvin Fox has joined the technical staff of Atomics International. Dr Fox, a well known figure in the American

MARVIN FOX

PROF EDWARDS

nuclear scene took part in the early work at Brookhaven and more recently—as director of the Internuclear Company he directed the consultant service to SENN.

Mr R. D. Baird, a grandson of the founder of Baird & Tatlock (London) Ltd has been appointed a director of the company and of Hopkin & Williams. Graviner Manufacturing Co Ltd have elected **Mr N. G. Bennett** to be joint managing director.

Dr D. J. Peery and **Dr J. C. Stewart** are new research staff members at General Dynamics Corporation's General Atomic Division. Dr Stewart was formerly at Knolls Atomic Power Laboratory.

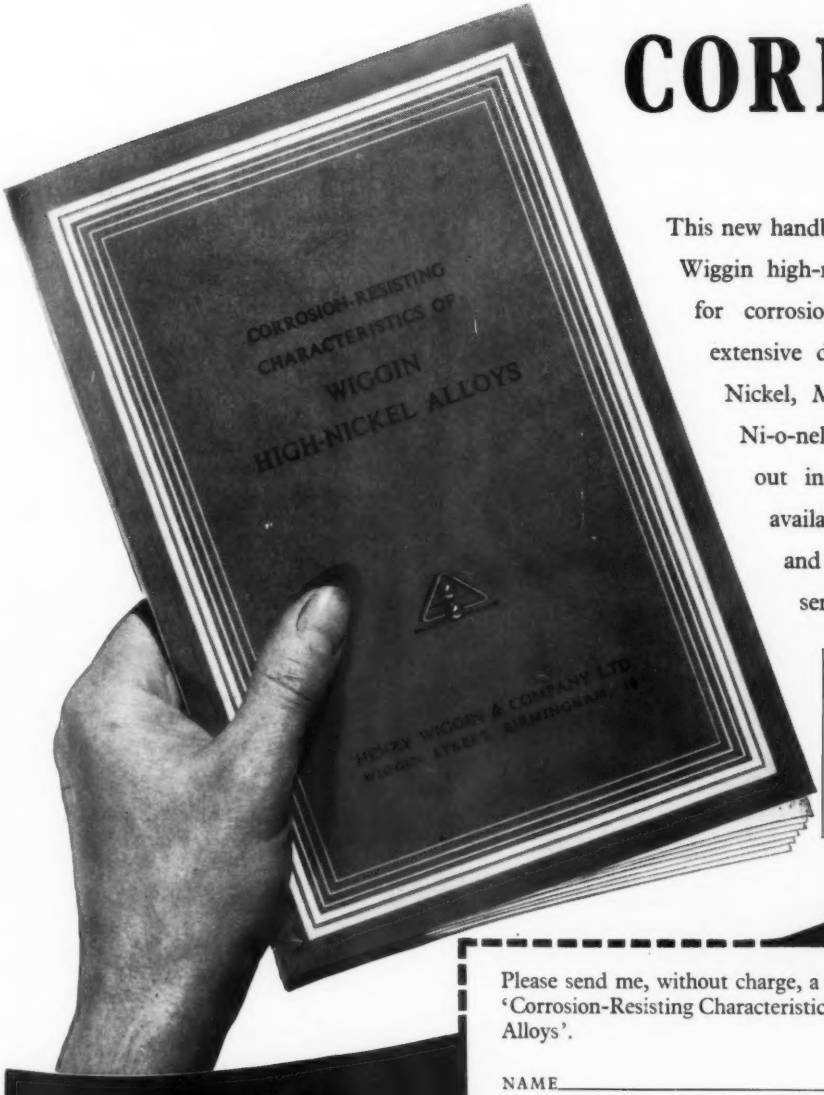
OBITUARY

Mr T. L. Eckersley, a well-known research worker in the field of radio-wave propagation who was associated for many years with Marconi's Wireless Telegraph.

Mr G. W. I. Nokes, general manager of Peabody Ltd.

Knowing where to find the answers on

CORROSION



This new handbook describes in detail the many Wiggin high-nickel alloys specially developed for corrosion-resisting duties. It includes extensive data on the properties of 'AT' Nickel, Monel, Inconel, Corronel B and Ni-o-nel, and gives results of tests carried out in many corrosive media. It is available, without charge, to designers and chemical engineers. May we send you a copy?

● **See our exhibition WIGGIN NICKEL ALLOYS in INDUSTRY Park Lane House, Park Lane, London, W.1. May 12th-15th 10 a.m.-8 p.m. Write for tickets and details.**

Please send me, without charge, a copy of your publication 'Corrosion-Resisting Characteristics of Wiggin High-Nickel Alloys'.

NAME_____

COMPANY_____

_____

Publications will be sent to private address, if preferred.

NP.

WIGGIN

***KNOW* NICKEL ALLOYS**

'MONEL', 'INCONEL', 'CORRONEL' AND 'NI-O-NEL' ARE REGISTERED TRADE MARKS

HENRY WIGGIN AND COMPANY LIMITED, WIGGIN STREET, BIRMINGHAM 16

TGA C5

They said...

points from papers, speeches, conferences

Cooperation or chaos?

International cooperation, control and assistance are essential if the International Atomic Energy Agency is to succeed said Sterling Cole, Director-General, when addressing the Ninth Annual Conference of the American Association for the United Nations on March 9. The Agency's policy should be based on the positive answer to three questions. 'Shall the atomic energy contributions of the technically and materially endowed nations to other countries be given and applied through truly international channels?'

'Shall the peacetime production and utilization of nuclear materials around the world be carried out under international codes and standards for health and safety?'

'Shall the nations seek in unison to establish and maintain uniform practical rules to prevent the diversion to military purposes of nuclear materials supplied for peaceful use?'

A positive answer to the first question would automatically cancel existing bilateral agreements for selective nation-to-nation exchanges. A similar answer to the second question would greatly facilitate the international movement of radioactive material and equipment whether it be isotopes or nuclear powered vessels. Unless a positive answer is given to the last question, nations 'may make their own rules and apply them as they deem desirable under unpredictable conditions of inter-nation competition.' To implement this policy and to make the procedure really workable direct contributions of funds should be made to the Agency and distributed by it to the atomically less advanced countries so that 'dependence upon a single donor' is avoided and the so-called atomic bilaterals taken over.

The International Agency already 'provides the framework' within which all these procedures could be carried out and there would be 'no question of preferential treatment' but if it is going to be successful in its activities it is essential that its recognition grows and the problems are resolved.

Summing up, the Director-General said that the measures outlined should not be taken as isolated steps but that they were closely related, inter-dependent and they formed a whole. While these policies cannot come into being overnight 'they will go far to establishing a healthy and growing atomic power industry in all parts of the world.'

Fuel problems reviewed

The possible availability of plutonium from nuclear power stations in the not too distant future should simplify the fabrication of fuel elements for marine reactors said Dr H. M. Finniston when presenting a paper to the Joint Panel on Nuclear Marine Propulsion in London on March 3.

Reviewing existing fuels he pointed out that uranium and its alloys are affected by irradiation in two ways—

H. M. FINNISTON
ceramics his bet

growth and swelling. To some extent heat treatment, by modifying the microstructural features of uranium reduces this growth and 'the more effective the quench the greater is the reduction in texture and the less the growth.' Attempts have been made to facilitate heat treatment by the addition of small quantities of alloying elements such as the American uranium-zirconium alloys. Growth is most extensive during burnup at approximately 200°C and decreases to zero at about 500°C.

When the temperature is raised to above 450°C the second phenomenon, swelling, assumes greater importance and is, in fact, the more difficult problem to solve. The primary cause of swelling is segregation of the fission product gases xenon and krypton which form bubbles by diffusion and nucleation. Swelling increases slowly with increasing temperature and more rapidly above 600°C; it increases with increasing burnup; it is dependent upon the rate of burnup and is not substantially affected by small additions of alloying elements. To date there is no known solution to swelling except by the addition of molybdenum but the high neutron cross-section and alloying costs prohibits the use of this alloying material.

A fortunate accident of scientific development led to the finding that uranium dioxide provided a material which is free from swelling at high temperatures; it has the added advantage that it is resistant to water corrosion at 300°C. Uranium dioxide could be 'alloyed' in two ways—by the addition of small amounts of other oxides or by its dispersion in either a metallic or non-metallic matrix.

With the production of large quantities of plutonium within the next ten years from the land-based nuclear power stations the shipping industry may well find itself using plutonium as its basic fuel as the limited experience to date indicates that this material could be tailored with good corrosion and irradiation resistance, not only for operation in water-cooled systems but even for high temperature applications. Also it should be possible to incorporate plutonium oxide in uranium dioxide without any major technical difficulty. Dr Finniston said this was one way the AEA could make a vital contribution to atomic engineering.

As a fuel element is only as good as its can, the properties of canning materials are as important as the fuel. Taking the combined requirements of comparatively low cost with high strength and good corrosion-resistance properties as being essential for marine reactor fuel cans and that enriched fuel will be used, stainless steel could be used to advantage for water- or gas-cooled reactor systems. Plutonium oxide and uranium dioxide could be used to provide an enriched fuel to overcome the disadvantage of the higher neutron cross-section of stainless steel.

When higher operating temperatures, between 1000 and 1500°C are to be encountered 'ceramics would be my bet' said Dr Finniston. After indicating that when uranium dioxide was dispersed in an alumina-based refractory made impervious by the addition of a glass-forming oxide, the xenon released at 800°C was only 0·03% he proposed as a long term policy that the ideal combination would be a ceramic type of fuel element using plutonium oxide and uranium dioxide matrix.

More for industry!—Iddles

Atomic energy development should be placed in the hands of industry where it can be accelerated through commercial competition and 'competition between the minds of man' proposed Mr Alfred Iddles, former president of the Atomic Industrial Forum and a director of the Babcock & Wilcox Co, at the Cincinnati Council on World Affairs Fifth Annual Conference recently.

STEEL, PEECH & TOZER

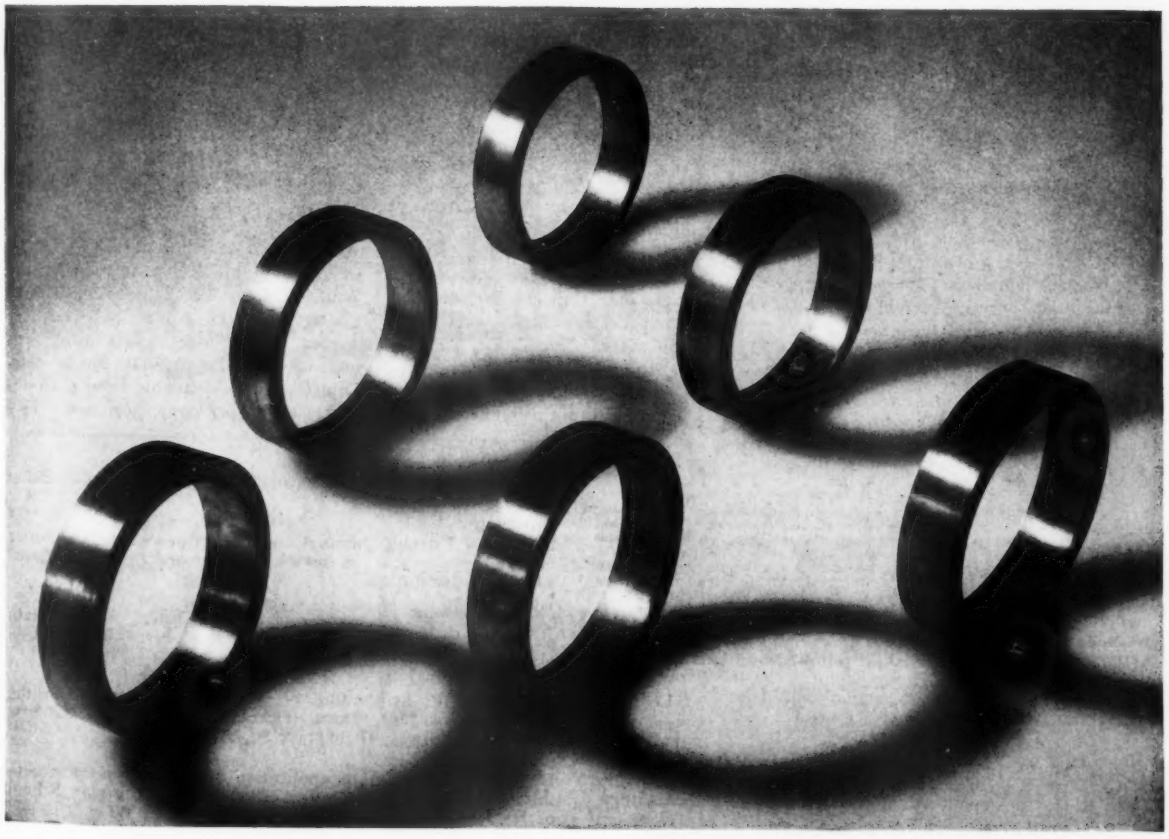
A Branch of The United Steel Companies Limited

P.O. Box 50, THE ICKLES, ROTHERHAM, YORKSHIRE

THE UNITED STEEL COMPANIES LTD

FORGED AND ROLLED STEEL RINGS

Rings in all sizes from 2" to approximately 96" in diameter and up to one ton in weight are produced by rolling, hand forging or upset forging, depending upon size. Profile sections can be rolled if ordered in quantity. A wide range of qualities from mild steel to highly alloyed steels may be specified.



SP 205

CATALOGUES AND BULLETINS

Steel supplies. The Birmingham firm of Stern & Bell has issued comprehensive stock lists of mild, high alloy, tool and stainless steels available for immediate delivery.
Tick **No 233** on reply card

Abbreviations. BEAMA publication No 159 entitled Abbreviations of associations, institutions, research and trade associations, has been enlarged and reprinted. Items included are those with particular reference to the electrical and allied industry. There is also an appendix of suffixes and qualifications.
Tick **No 234** on reply card

Valve data. Handy abridged valve catalogue from English Electric gives at-a-glance technical details on rectifiers, triodes, thyratrons, magnetrons etc.
Tick **No 235** on reply card

Electricity in industry. No 16 of this Lancashire Dynamo publication is now out—includes an article on variable speed drives reviewing the development of equipment incorporating electronic and magnetic amplifier controls.
Tick **No 236** on reply card

Fan and blower noise. Interesting booklet from Keith Blackman called 'A test code for acoustical measurement of centrifugal, axial and propeller fans' deals with a subject which has, as yet, no authoritative test code.
Tick **No 237** on reply card

Springs. Constant force and constant torque springs manufactured by Tensator Ltd are said to have a new elastic element which greatly increases accuracy. Leaflet describes.
Tick **No 238** on reply card

Prefabs. Well illustrated brochure gives technical and general information on Cosely prefabricated buildings. Range includes factories, storage accommodation and housing accommodation.
Tick **No 239** on reply card

Degreasing plant. ICI have introduced a standard range of totally enclosed mechanized trichloroethylene degreasing plant. Leaflet describes.
Tick **No 240** on reply card

Temperature measurement. Technical publication TP5039 from George Kent is by H. G. Oughton on Primary elements for temperature measurements.
Tick **No 241** on reply card

Metal bending. Vertical presses and cold benders used in a variety of fields are detailed in colourful leaflet from Finlay Engineering Ltd. Special hydraulic units can also be designed.
Tick **No 242** on reply card

Hilger spectrographs. Equipment for spectrochemical analysis is described under three main headings, three-metre grating polychromator, medium direct-readers, fluorite polychromator.
Tick **No 243** on reply card

Air filters. Vokes have produced an entirely new range of fibreglass air filters which are of particular interest where initial costs are a primary consideration.
Tick **No 244** on reply card

English Electric publications. Four new items have been issued. Titles are Air-blast switchgear, Steam turbines, Geared steam turbines, A new welding electrode. Booklet on steam turbines includes some excellent sectional illustrations.
Tick **No 245** on reply card

Electronic timers. Delay switches, process and cyclic timers are described in data sheet from Elcontrol who emphasize their interest in producing complete sequence control panels for special requirements.
Tick **No 246** on reply card

Advanced Materials Technology. This quarterly magazine from Carborundum is available free of charge. Recent number contains article on zirconium alloys.
Tick **No 247** on reply card

Counting instruments. General catalogue R from Nuclear Chicago Corporation gives full specifications and details of their entire range.
Tick **No 248** on reply card

Motor controls. Brochure from Igranic Electric describes firm's new interchangeable, extensible control centres containing withdrawable panels.
Tick **No 249** on reply card

Wire filters. Range of grids, grills, sieves screens, strainers, and filters is described briefly in new folder from Endecott's (Filters) Ltd.
Tick **No 250** on reply card

Cast iron. Full specification and mechanical properties of Icanite special process cast iron are contained in brochure from the Incandescent Heat Co Ltd. Advantages claimed are close grain, shock and abrasion resistance.
Tick **No 251** on reply card

Thermocouples. Second edition of 'Noble Metal Thermocouples' by H. E. Bennett was recently published by Johnson Matthey & Co Ltd. It is available free.
Tick **No 252** on reply card

U-Al elements. 4-page technical data bulletin NU-3 from M. & C. Nuclear Inc includes information on fabrication and technical specifications.
Tick **No 253** on reply card

Transducer. New pressure resistance transducer, now available commercially is described in leaflet from KDG Instruments Ltd.
Tick **No 254** on reply card

Feed pumps. Brochures from G. & J. Weir Ltd illustrate briefly types SD turbine driven feed pumps and QB.
Tick **No 255** on reply card

Valves. Subject of recent UKAEA contract 'Scotomic' stainless steel diaphragm valves for 250 psi 250°C by Scotts Engineering (Newport) Ltd are described in brochure from the firm.
Tick **No 256** on reply card

Valves. For fluids and gases up to 600°C High Pressure Components Ltd have introduced their model A575. Leaflet available.
Tick **No 257** on reply card

World Reactor Catalogue
In response to numerous requests the World Reactor Catalogue published in January NUCLEAR POWER has been reprinted. Minor amendments have been included to bring it fully up to date. Copies are now available from the publishers at 2/- per copy, post free.

APRIL DIARY

ICE Institution of Civil Engineers, IMechE Institution of Mechanical Engineers, IEE Institution of Electrical Engineers, IChemE Institution of Chemical Engineers, IP Institute of Physics, PS Physical Society, SCI Society of Chemical Industry, IM Institute of Metals, IMet Institution of Metallurgists, IMM Institution of Mining and Metallurgy, IPE Incorporated Plant Engineers, SIT Society of Instrument Technology, BritIRE British Institution of Radio Engineers, RSH Royal Society of Health, IR Institute of Refrigeration.

WEDNESDAY 1
MIDDLESBROUGH IEE AGM followed by Electrification of the UKAEA Industrial Group factories *J. W. Binns, W. J. Outram* 6.30 Cleveland Scientific and Technical Institute, Corporation Rd

THURSDAY 2
MANCHESTER BritIRE Principles of transistor circuitry *B. R. A. Bettridge* 6.30 Reynolds Hall, College of Technology, Sackville St

WEDNESDAY 8 to FRIDAY 10
OXFORD PS Conference on nuclear physics at the Clarendon Laboratory

FRIDAY 10
LONDON IMechE James Clayton Lecture Canadian atomic energy development in review and prospect *W. B. Lewis* 6.00 at the Institution

THURSDAY 16
LONDON SIT self-optimizing control system for a certain class of randomly varying inputs *A. P. Roberts* 6.00 Manson House, Portland Place, W1

FRIDAY 17
LONDON IP Symposium on Current developments in the production of high vacua Tickets etc from the Secretary, Institute of Physics, 47 Belgrave Sq, SW1

WEDNESDAY 22
LONDON BritIRE The application of magnetic resonance to solid state electronics *D. J. E. Ingram* 6.30 London School of Hygiene and Tropical Medicine, Gower St, W1

New! all-in-one

SCALER 1700

Look at these Features!

1. Fast Scaler with 9 pre-set count positions.
2. Electronic Timer with 9 pre-set time positions.
3. Triple range ratemeter with long and short time constants.
4. Single Channel Pulse Height Analyser.
5. 250 to 2000V stabilised H.V. supply.
6. Linear Amplifier, sensitivity 5mV – 50V.
7. Every equipment has 100 hour "Soak Test".
8. "Chimney" construction reduces internal heating.
9. Conservative rating of all components.
10. Sound mechanical engineering.
11. Immediately replaceable plug-in printed circuit boards for more than 80% of the equipment.
12. Quick release top and bottom covers give complete access to interior.
13. More than 90% of tubes internationally available.
14. Operates directly with most types of radiation detectors.
15. Power supplies for external Head Amplifier or Quench Unit.
16. Will operate printing register.
17. Connection for count rate recorder.
18. Tilt-up stand fitted for convenient viewing.
19. Main functions push button selected.
20. Converts Easily to Rack Mounting Unit.
21. Recommended spares kit available.

Write for detailed specification:

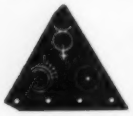
I D L NUCLEONIC EQUIPMENT

ISOTOPE DEVELOPMENTS LTD.

BEENHAM GRANGE, ALDERMASTON WHARF, NR. READING, BERKS. Tel: Woolhampton 451
LONDON OFFICE
120 Moorgate, London, E.C.2. Tel: Met. 9641.

Tick **No 85** on reply card for further details

Tick No 262 on reply card

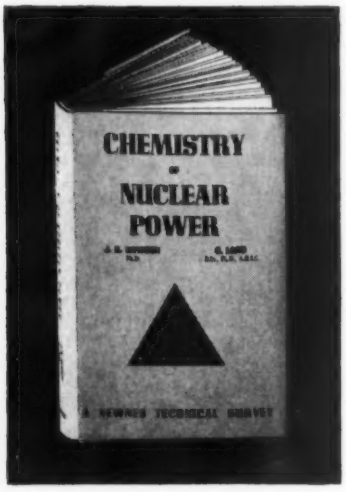


Just published!

CHEMISTRY OF NUCLEAR POWER

by

J. K. Dawson, Ph.D., F.R.I.C. and G. Long, Ph.D., A.R.I.C.



A Newnes Technical Survey

A highly authoritative account of the vital part played by chemists in the overall programme of nuclear power. The authors, both of whom are at the Chemistry Division, Harwell, are well qualified to give a broad picture of established practice, present lines of thought and indication of future problems.

CONTENTS

Role of Chemists in the Industry Raw Materials . Fission and Its Products . New Heavy Elements Separation Processes . Handling of Radioactive Materials . Reactors Disposal of Radioactive Waste Future Applications . Index . Illustrations.

From all booksellers or in case of difficulty at 31s. 3d. post free from George Newnes Ltd., Tower House, Southampton Street, London, W.C.2.

30s. net

NEWNES

Book Reviews

From the Russian

The Geology of Uranium London 1958: Chapman & Hall 128 pp Price 48s

This collection of twelve papers translated from the Russian covers a wide field from mode of occurrence and detailed mineralogy, to aerogeophysical prospecting and radiometric ore analysis.

Three papers describe occurrences of uranium in the Soviet Union and possible modes of origin. Both V. S. Karpenko and R. V. Getseva cover occurrences in which the formation of ore is attributed to metamorphic redistribution. Getseva describes the formation of ore bodies in regionally metamorphosed geosynclinal sediments, and expresses ideas approximating to those expressed by Dr Anton Gray in a recent Wernher Memorial Lecture to the Institute of Mining and Metallurgy, concluding that the ore bodies result from redistribution of the metal during folding. The mechanism suggested is dehydration, destruction of adsorption bonds, and liberation and migration of the metal following the release of pressure and introduction of pore solutions. Evidence is presented for the fixation of uranium by the reducing action of organic material and sulphur.

The texts are plentifully illustrated with photomicrographs and radiographs, as is that in which Z. A. Nekrasova argues an epigenetic against a syngenetic origin for uranium mineralization in a coal series. The powerful leaching effected by water rich in calcium bicarbonate is invoked here as the medium of transportation.

Much of the book consists of a useful compilation of mineralogical data concerning a few rare, and several more common, uranium minerals. Photomicrographs and radiographs are used together with thermal curves, optical, chemical and X-ray data. The data on Nenadkevite, a quadrivalent uranium mineral first described by N. A. Polikarpova in 1956, is amplified, and Z. A. Kikrasova writes on uramphite and compares its physical constants with those of the synthetic product. Ursilite, another recently recognized uranium silicate is described, and an interesting synthesis of uranite is recorded.

Thermal investigations into some of the commoner secondary minerals will be of interest to laboratory workers in this field. The role of water in the crystal structure of these minerals is discussed on the basis of dehydration effects on the crystal lattice.

The book also contains a detailed discussion of the radiometric method of analysing radium- and thorium-bearing uranium ores, and a simple review of aerogeophysical prospecting.

To those concerned with the geology and mineralogy of uranium, this book will be a useful addition to the library, as much mineralogical data is brought together, and ore occurrences in the Soviet Union are described.

J. R. Jay

Basic principles

Chemical Processing of Nuclear Fuels by F. S. Martin and G. L. Miles London 1958: Butterworths Scientific Publications Price 40s

In their preface the authors claim that this book is primarily concerned with the problems of the chemical processing of irradiated nuclear fuel and that the emphasis is on basic principles rather than technology. There is little mention of plant design and virtually no description of the specialized equipment which has been developed by the USAEC and the UKAEA. In fact, the book is mainly devoted to a description of the *chemistry* of nuclear fuel processing and not to the processing itself. The title is therefore misleading.

Up to now aqueous methods have almost universally been used for processing irradiated fuels, whereas studies of non-aqueous methods are still confined to the laboratory or pilot plant. The chapters describing the principles of non-aqueous methods, however, form an admirable account of the present position in the subject. The chapters on the much more important aqueous methods are less satisfactory. These start with a long discussion of the basic chemistry of the heavy elements, fission products, and other materials of technological importance. This discussion is more detailed than is necessary for the general science or engineering graduate. On the other hand, solvent extraction is described in a very short chapter which is quite inadequate even for the limited aims of this book. Other chapters describe nuclear fuel characteristics, fuel cycling, economics of processing, effluent disposal, fission product recovery and future trends in fuel processing. Only a passing reference, if any, is made to such topics as criticality and its influ-

PRECISION ENGINEERING
FOR NUCLEAR POWER PLANT EQUIPMENT

SPERRY

Control and Instrumentation

Complete Reactor Control Head Mechanisms

Servo-Driven Control Rod Position Indicators

Pulse-Driven Control Motors

Synchro Units, High and Low Temperature Operation

Servo Motors

Magnetic Particle Clutches

Inductive Pick-offs

Non-Destructive Flaw-Detecting Instruments

Magnetic Storage Drums for Data-Handling Equipment

Electro-Hydraulic Servo Valves

Complete Systems Engineering Facilities

Write, call or telephone your enquiries to the Sperry Gyroscope Company Limited, Great West Road, Brentford, Middlesex. ISLeworth 1241

Engineering, Marine, Welding and Nuclear Energy Exhibition
APRIL 16th TO 30th, STAND No. 9, ROW F GRAND HALL

Tick **No 86** on reply card for further details

Tick **No 263** on reply card

BOOK SERVICE

All the books reviewed in *Nuclear Power*, and all other scientific and technical books and periodicals from all over the world may be obtained from:—

BLACKWELL'S

BROAD STREET
OXFORD

Get all the
latest information
from our catalogues of new books on
Science
and
Technology

free on request

NUCLEAR POWER BOOK INQUIRY SERVICE

If you would like to have details of a particular book or to know whether one is published on a specific subject, fill in this coupon and send it to us. We will then forward it to the appropriate publisher or bookseller who will answer your query.

NAME .....

ADDRESS .....

.....

Details please of books on the following subjects:

.....

.....

.....

.....

.....

send to **NUCLEAR POWER, 3 PERCY STREET, LONDON, W1, ENGLAND**

ence on plant design, shielding factors, radiation decomposition of process reagents, process equipment, etc.

The subject matter is drawn largely from papers published prior to 1957 and from the Proceedings of the first Geneva Conference. Since then there has been the second Geneva and many important papers were presented at this which are relevant to a discussion of the chemical processing of nuclear fuels—particularly to the technology of the subject.

This book can be recommended to the science or engineering graduate who desires more information about the basic chemistry of nuclear fuel processing, and who does not expect to find a discussion of the associated technology.

G. R. Hall

Techniques for industry

Glove Boxes and Shielded Cells Edited by G. N. Walton London 1958: Butterworth's Scientific Publications 515 pp Price £4 15s

In February, 1957, a symposium on this subject was organized by Harwell, and this is the proceedings, arranged in chapter form in an order which develops the subject logically. It is clear that the Editorial Board have been at pains to ensure coherence and an absence of the scrappiness which can so easily arise from this form of book-making.

This is a substantial book of some 500 pages at a price as high and discouraging as we have become accustomed to expect, but it should serve a very desirable purpose of conveying, beyond the esoteric few, what is known about handling radioactive materials. The use of these techniques is, in an embryonic sense, a part of industrial technology now and there will be a rapid spread as reactor types and techniques develop. The editors have done well to impart a sense of unity which makes the book useful both for reference purpose —for there is a lot of design detail— and for the general reader to obtain a broad grasp of the principles covered. It is of some regret, no doubt to the Editors as much as to the readers, that no contribution from the USSR could be included and that the material submitted from the US does not proportionately represent knowledge in that country, particularly with regard to shielded cells and 'over the wall' manipulators. Bearing in mind the origin of the book the flavour must inevitably be British and this is, perhaps, carping comment. However, in such a rapidly developing technology, the engineer must keep his eye on progress everywhere and, fortunately in this respect, several Russian papers presented at last year's Geneva conference supplement this book to some extent and help to give a total view.

J. G. Ball

Tick **No 264** on reply card

CHAPMAN & HALL

PHYSICS AND HEAT TECHNOLOGY OF REACTORS

Supplement No. 1 of the Soviet Journal of Atomic Energy

Translated from the Russian and published in co-operation with
CONSULTANTS BUREAU, INC.
NEW YORK

180 pages *Illustrated* *168s. net*

The nineteen original papers in this volume may be conveniently divided into two groups. The first group deals with reactor physics and the papers in it encompass a wide circle of problems which have not been studied to any great extent nor treated in the literature. The second group is concerned more with problems of an engineering nature, such as those of heat arising in, and heat removal from, power reactors.

37 ESSEX STREET, LONDON, W.C.2

NEW BOOKS

on Atomic and Nuclear Physics

(General, Advanced and Applied) Supplied from stock. Foreign books not in stock obtained to order. Catalogues on request.

SECOND-HAND BOOKS

A constantly changing large stock of Scientific and Technical Literature on view, classified under subjects.

LENDING LIBRARY

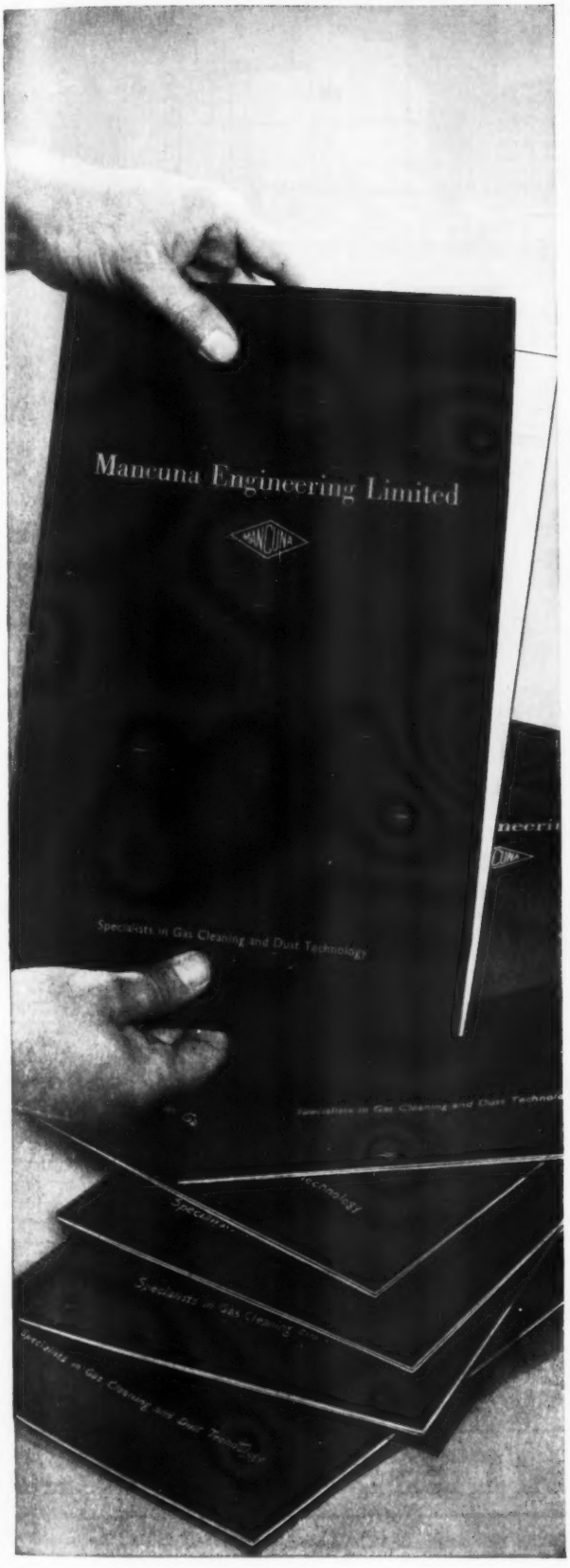
Technical and Scientific

Annual Subscription from £1 . 17 . 6. Bi-monthly list of New Books and New Editions sent post free to all subscribers on request. Prospectus post free on application.

H. K. LEWIS & CO. LTD

136 Gower St. W.C.1. EUS 4282

Tick **No 265** on reply card



Memorandum on a dangerous subject

The creation of dusts infinitely more dangerous than anything previously known to mankind has given impetus to a 'new look' at the problems so far experienced, and the methods and equipment available to combat these problems. Mancuna Engineering Limited have been in the forefront of those few Companies who have recognised the exceptional nature of the demands which would have to be met in nuclear energy installations. Their latest memorandum describes the technical and scientific approach being applied to gas cleaning and dust collection and provides the nuclear energy engineer with an appreciation of the equipment available to him. *A brief request on your firm's letterhead will ensure you a copy.*

MANCUNA ENGINEERING LIMITED

Specialists in Gas Cleaning and Dust Technology

DENTON · MANCHESTER

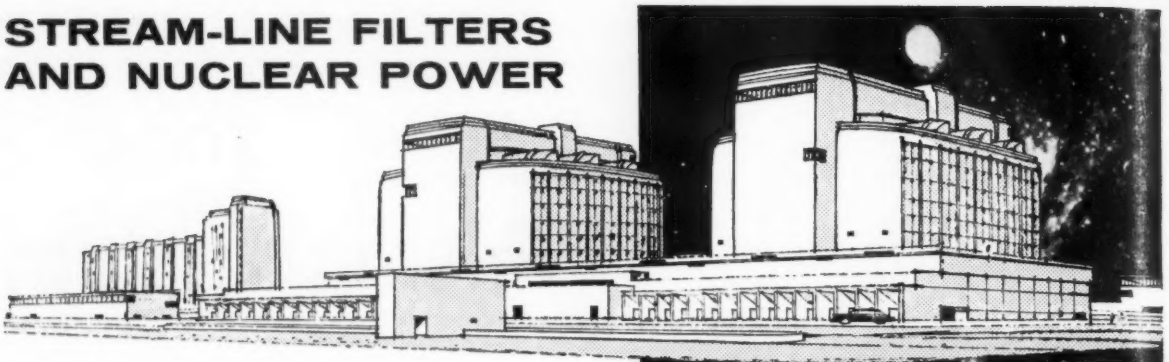
Phone: DENTON 3965 (5 lines)

London Office: 59 VICTORIA ROAD
SURBITON · SURREY
Phone: Elmbridge 9793

Tick **No 87** on reply card for further details

Tick **No 88** on reply card for further details

STREAM-LINE FILTERS AND NUCLEAR POWER



The security of oil-immersed circuit breakers or transformers depends on the condition of the oil. In Stream-Line filters the engineer has at his disposal equipment specially designed for the complete removal of contamination in insulating oil and which meets the most stringent requirements. That's why Stream-Line filters have been specified for Chapel Cross and Berkeley, and are in wide use throughout the U.K.A.E.A. A single passage through a Stream-Line filter ensures the elimination of solid impurities, even the finest colloidal carbon; dehydration, including the removal of dissolved water, and de-aeration, including the removal of dissolved gases. A dielectric strength far above that specified for the highest quality new oil is achieved by a standard Stream-Line filter. Our research and development department will be glad to answer your queries. Write for Catalogue W. 1031.

A WORD ABOUT HIGH VACUUM

Stream-Line filters designed to operate under high vacuum can be supplied. Details are available on request of models yielding remarkable performances. For most requirements the standard Stream-Line filter gives precisely the service demanded.

A fully mobile Stream-Line filter.

STREAM-LINE FILTERS

STREAM-LINE FILTERS LTD · INGATE PLACE · LONDON · S.W.8

A member of the VOKES Group

Telephone : MACaulay 1011

SF 29

MAKE LIFE EASIER with the PRICED STAINLESS STEEL STOCK LIST

Look first at the largest and most comprehensive Stock List in the Country. Mill prices and foot/lbs. weights are shown against every item. The stock list is revised and mailed every sixty days. Write or phone for your copy today.

ANY QUANTITY AT MILL PRICES. AID-ARB approved.

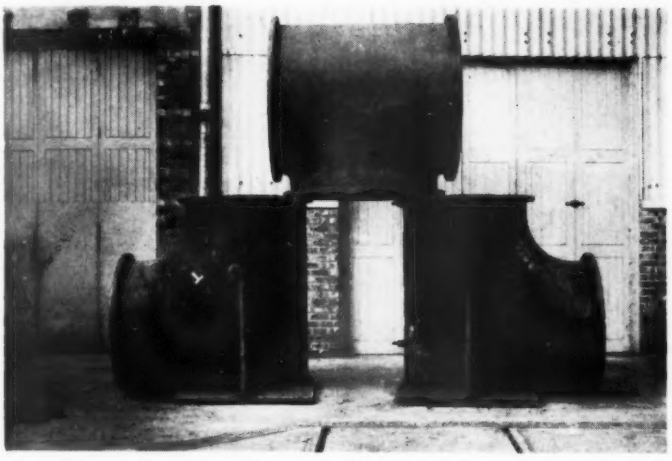
TAYLOR STAINLESS METALS LTD.

BRITAIN'S PRINCIPAL STAINLESS STEEL STOCKHOLDERS.

BUCKINGHAM AVENUE · SLOUGH · BUCKS · TEL: SLOUGH 24551

and at UNION CHAMBERS, 63 TEMPLE ROW, BIRMINGHAM 2 TEL: Midland 1450

CLAY CROSS



for
water
cooling
and
drainage
systems

VERTICALLY CAST IRON PIPES
SPECIAL PIPE CASTINGS

BENDS, TEES, TAPERS, ETC. UP TO 84" DIAM.

SPUN IRON PIPES

SCREWED SPUN FLANGED

work in progress for the nuclear industry

CLAY CROSS (IRON & FOUNDRIES) LTD.

CLAY CROSS, DERBYSHIRE

Telephone: Clay Cross 2151 *Telegrams: Jackson, Clay Cross*

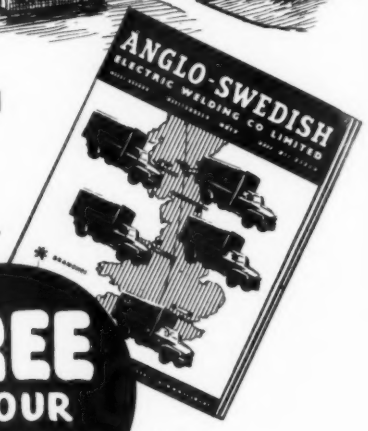
Tick **No 91** on reply card for further details

ANGLO-SWEDISH

ELECTRIC WELDING CO. LTD

FOR FIRST CLASS WELDING
UNDER THE STRICTEST SUPERVISION

We have ample facilities for handling top-grade welding repairs to boilers, castings, machine parts, etc.—with expert technicians for Fabrication work, Structural Steel work, Tank construction and Electric Stud Welding. Let us send you this descriptive colour brochure.



For immediate service contact us NOW—

ANGLO-SWEDISH ELECTRIC WELDING CO LTD
WOOD WHARF · GREENWICH · LONDON SE 10
Telephone: GREENWICH 2024-5

NEWCASTLE · LIVERPOOL
GLASGOW · LEITH · LONDON

FREE COLOUR BROCHURE

'HYDROBORD'

for

NEUTRON SHIELDING

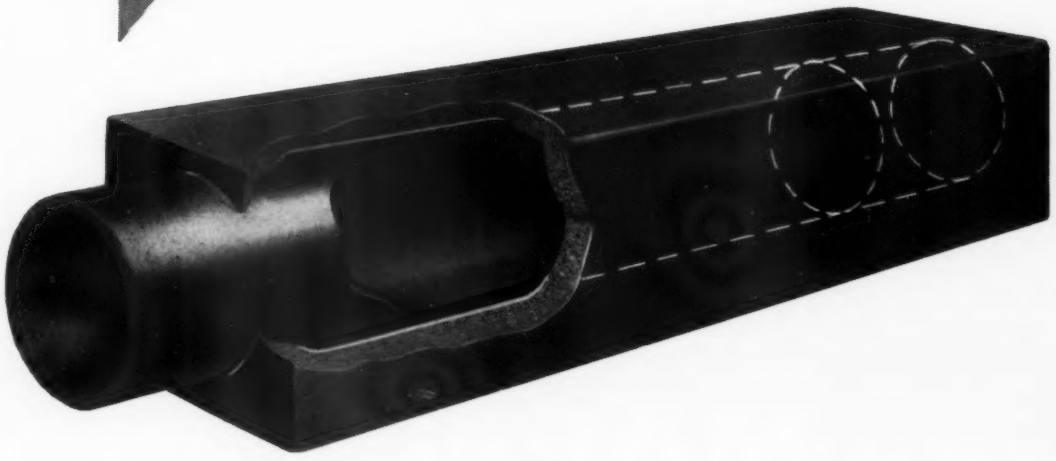
HYDROBORD provides insulation against Fast and Thermal Neutrons or combinations of both.

William Mallinson and Sons Ltd.

130 HACKNEY ROAD · LONDON · E.2
Telephone: Shoreditch 7654
Telegrams: 'Almoner', London

Tick **No 92** on reply card for further details

MACHINING OF NUCLEAR GRAPHITE UNDER CLEAN CONDITIONS



by Powell Duffryn

DELANIUM CARBON & GRAPHITE

CARBON PRODUCTS LIMITED

SPRINGFIELD ROAD, HAYES, MIDDLESEX TELEPHONE: HAYES 3994

Tick **No 95** on reply card for further details

Man and Method

The result of this craftsman's work will be an interior surface, smooth as silk—without blemish, and completely safe for the bulk transportation of edible liquids.
He is skilled and proud of it and, like his colleagues in other crafts, he meets the exacting demand set by Darham in the construction of road tanks, transportable tanks and storage tanks for customers in countless industries at home and overseas.

DARHAM TECHNICAL ADVISORY SERVICE is on call to you. If you would have tanks that are accepted as a standard by which others are judged you will seek the advice of Darham.

DARHAM build fine tanks in Mild Steel (suitably lined if necessary), Stainless Steel and Aluminium.

Darham

DARHAM INDUSTRIES (LONDON) LIMITED
17 Surrey Street, Strand, London, W.C.2.
COVent Garden 0556
WORKS: BASILDON ESSEX AND DURHAM CITY

JOHN THOMPSON GROUP

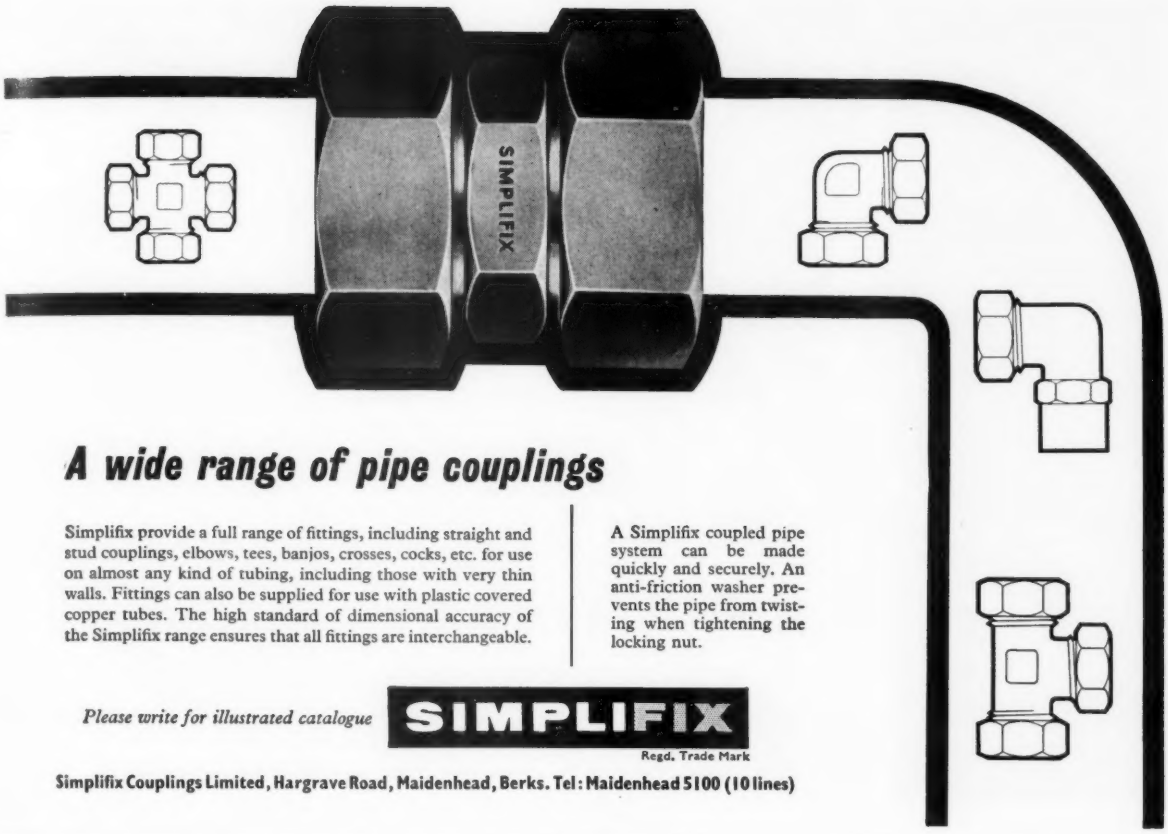
for CATHODIC PROTECTION

or WELDING INSPECTION

call in MAPEL

MAPEL

METAL & PIPELINE ENDURANCE LTD.,
Artillery Mansions, Victoria Street, London, S.W.1.
Tel: ABBey 6056 'Grams: Metaldure, Sowest, London
Divisional offices at Woolmer Green, Herts; also at Newcastle upon Tyne and Glasgow
AGENTS THROUGHOUT THE WORLD



A wide range of pipe couplings

Simplifix provide a full range of fittings, including straight and stud couplings, elbows, tees, banjos, crosses, cocks, etc. for use on almost any kind of tubing, including those with very thin walls. Fittings can also be supplied for use with plastic covered copper tubes. The high standard of dimensional accuracy of the Simplifix range ensures that all fittings are interchangeable.

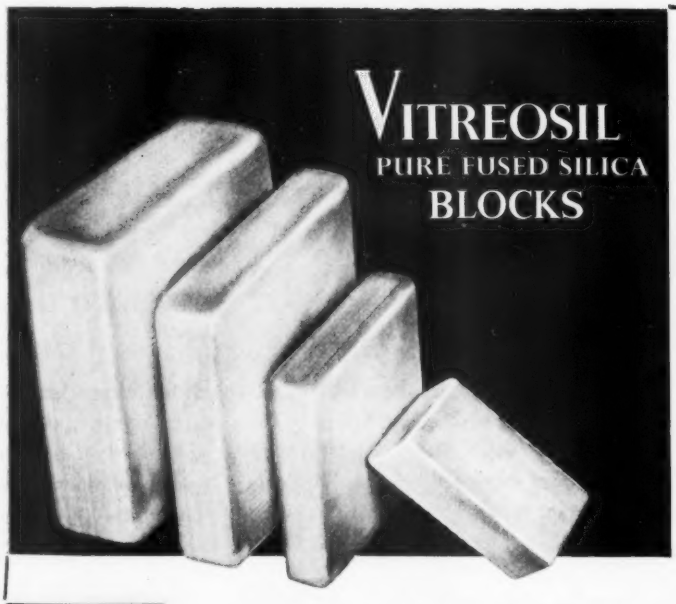
A Simplifix coupled pipe system can be made quickly and securely. An anti-friction washer prevents the pipe from twisting when tightening the locking nut.

Please write for illustrated catalogue

SIMPLIFIX

Regd. Trade Mark

Simplifix Couplings Limited, Hargrave Road, Maidenhead, Berks. Tel: Maidenhead 5100 (10 lines)



Vitreosil Pure Fused Silica Blocks are now available up to 36″ × 18″ × 18″; larger sizes are under development.

Present applications are for special glass melting furnaces and constructions where freedom from contamination and stability at high temperatures are desired.

Your enquiries will be given prompt attention.

TSL
SERVICE TO SCIENCE

THE THERMAL SYNDICATE LTD.

P.O. Box No. 6 WALLSEND, NORTHUMBERLAND. *Tel: Wallsend 6-3242*

LONDON: 12-14 OLD PYE ST., WESTMINSTER, S.W.1. *Tel: ABBey 5469*

HEAVY DUTY
SPANNERS

Precision Hand Tools are of paramount importance to the Engineering Industry. King Dick hand tools are precision made under carefully controlled conditions, and set a superlative standard in quality and design. From the largest Constructional Engineering Tools to the smallest B.A. Socket Set, King Dick inspection routines ensure the correct combination of selected steels, perfect balance and precision.

Send for illustrated catalogue giving complete range of King Dick Hand Tools.

BINGDON
KING DICK
PRECISION HAND TOOLS

ABINGDON KING DICK LTD., Abingdon Works, Tyseley, Birmingham 11, England
R.E. 216

Quality Forgings

IN CARBON OR ALLOY STEELS TO B.S. SPECIFICATIONS . . .

. . . or to customers own specifications. The stringent requirements of present day engineering call for homogeneous forgings in carbon and alloy steels which conform rigidly to defined standards. Mountford forgings are backed by over 80 years' experience, an important factor when you demand absolute reliability.

We will be pleased to send you descriptive literature.

FORGEMASTERS SINCE 1872

JOHN MOUNTFORD and CO LTD
MANCHESTER, 11 **Telephone : EAST 2006 (three lines)**
Included on Lloyds, Admiralty and Ministry of Supply Inspectoral Lists.

Tick **No 101** on reply card for further details

in the NUCLEAR SPHERE

our products are many and varied

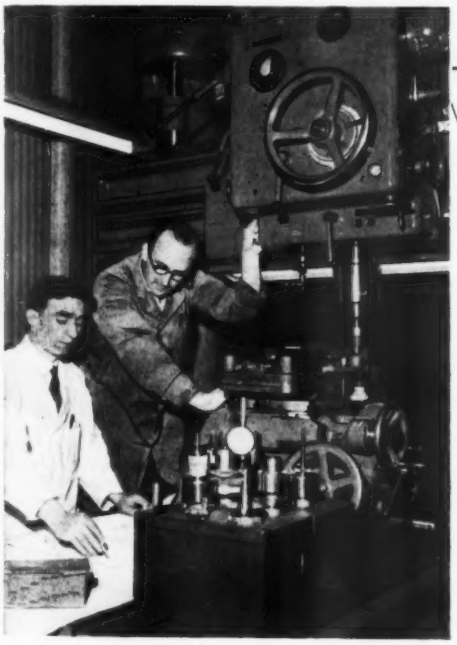
This Spherical Surge Vessel, 14 ft. in diameter and fabricated in ¾" thick aluminium alloy to specification NP5 was manufactured at our works in Witton.

The vessel was welded by the Argon Arc process throughout, the entire welding finally x-rayed. The vessel was then crack-detected, pickled, and finally vacuum tested.

Your enquiries will meet with our immediate attention.

THE LONDON ALUMINIUM CO. LTD.

WESTWOOD ROAD · WITTON · BIRMINGHAM 6 · ENGLAND



This way

for advanced engineering

Aeronautical engineering is an excellent school for nuclear engineering. That is the reason for this advertisement. Armstrong Whitworth have been concerned with aeronautical engineering right from its infancy. Our machine tools and their highly skilled operators are now tackling a wide variety of engineering problems. We might well be able to help you. Write or telephone to:

SIR W. G. ARMSTRONG WHITWORTH AIRCRAFT LIMITED
BAGINTON, NR. COVENTRY. TOLLBAR 2261.

Tick **No 102** on reply card for further details

Cast Iron Work of all Descriptions and to Special Metal Mixtures

Please Send US Your Enquiries

TWO OF THE TWELVE 72″ DIA CAST IRON BREECHES PIPES WITH 39″ DIA BRANCHES, WEIGHT APPROXIMATELY 7 TONS EACH. PART OF A RECENT ORDER IN CONNECTION WITH A LARGE STEAM CONDENSING PLANT.

C. & W. WALKER LTD.

Telephone: - LILLESHALL - SHROPSHIRE 371 (4 LINES)

MIDLAND IRONWORKS . DONNINGTON . NR. WELLINGTON · SHROPSHIRE

Variac with Duratrak*

for high-efficiency voltage control

VARIAC is the original continuously-adjustable auto-transformer, providing a smoothly variable output voltage from zero to 17% above line. Ultra-low-loss 'rolled' core and DURATRAK (patent) track surface give very high efficiency at all settings. A very wide range of models is available, from small units (e.g. type V-5, illustrated on right) for laboratory and instrument use to large ganged assemblies for three-phase power.

VARIACS can be supplied open or covered, as single units or ganged assemblies of two or more units, for manual operation or motor-driven. The range includes portable models, metalclad models, dual-output models, high-frequency types, and many 'specials'.

*DURATRAK is a rhodium-covered, silver-plated track surface, which inhibits oxidation of the brush track and greatly reduces contact resistance, giving longer life, increased overload and surge capacity and maximum economy in maintenance.

Type V-5HMTF, a small VARIAC for laboratory use. Output 0-270 V, continuously adjustable, from 230 V 50 c/s mains. Rated current 2 A. Provided with terminals, switch, fuse and 3-core lead.

For complete information on the entire VARIAC range, request **Catalogue 424-UK**

Claude Lyons Ltd.

VARIAC and DURATRAK are registered trademarks DURATRAK is protected by U.K. patent No. 693406

Only VARIAK has DURATRAK

76 OLD HALL ST LIVERPOOL 3 · Tel: CENTRAL 4641-2

VALLEY WORKS · HODDESDON · HERTS · Tel: HODDESDON 3007-8-9

CL/46/E2A

Tick **No 105** on reply card for further details

industries atomiques

International review for the peaceful application of nuclear energy

INDUSTRIES ATOMIQUES
is the only international technical and industrial review printed in French, which specialises entirely in nuclear and related subjects.

INDUSTRIES ATOMIQUES is read by industrialists, engineers, technicians and chemists, heads of technical firms and by all those engaged in the world of science. In short, it is intended expressly for all specialists interested in research and in its practical realisation.

In view of its international character, **INDUSTRIES ATOMIQUES** is read and appreciated in countries all over the world.

Up to date, more than 150 authors, all specialists, have honoured this review with their collaboration, and have contributed **previously unpublished** articles of high scientific value, abundantly illustrated.

INDUSTRIES ATOMIQUES is a source of precise documentation, constantly being brought up to date. The international information and the list of suppliers to the atomic industries printed in its pages will be found invaluable.

Annual Subscription

12 numbers per year	
French francs	4,150
Belgian francs	510
Swiss francs	35
U.S. dollars	8
Pounds sterling	3

Industries Atomiques Subscription form

Subscriptions can be paid in the currency of the country at any European post office.

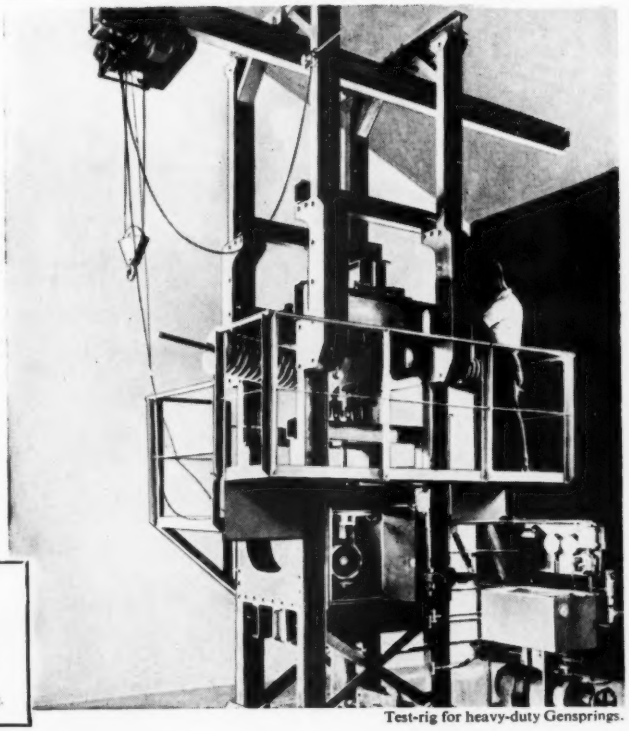
We desire _____ annual subscriptions, starting from _____, to be sent to (surname, Christian names, or firm's name, and address _____

Method of payment _____ Date and signature: _____

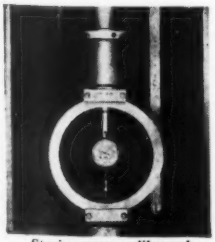
(This form should be returned in a stamped and addressed envelope to NUCLEAR POWER, 3 Percy Street, London, W1.)

We **prove** Gensprings can take it

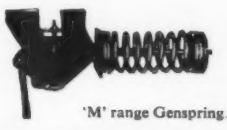
As an engineer you aren't satisfied with unfounded claims—you want proof. That's why we take pride in providing it. Take our Gensprings Hangers for example, MAXIMUM DEVIATION IS NOW GUARANTEED AT NOT MORE THAN 2%. On a special hydraulically operated test-rig at Guildford, we check every Genspring to ensure accurate load measurements over the full range including overload; the strain gauge was calibrated by the National Physical Laboratory. In fact every single Genspring is tested on this, or smaller rigs, and Test Certificates completed by our Inspection Department are available at the time of despatch. If further adjustment is required on site we will supply the revised settings. Full instructions regarding installation are available with each consignment, and if desired you can have the instructions in advance. Recently an *independent* research laboratory carried out a ten week corrosion test on a Genspring. Using the A.R.E. salt droplet test (B.S.S. 1931. 1952) they prove that the equivalent of 20 years exposure to severe marine atmospheric conditions had no appreciable effect on the Constant Support Hanger's mechanical efficiency. A copy of the report is available on request. Please write for catalogue covering the full range of Vokes Genspring pipe supports.



Test-rig for heavy-duty Gensprings.



Strain gauge, calibrated by the N.P.L.



'M' range Genspring.

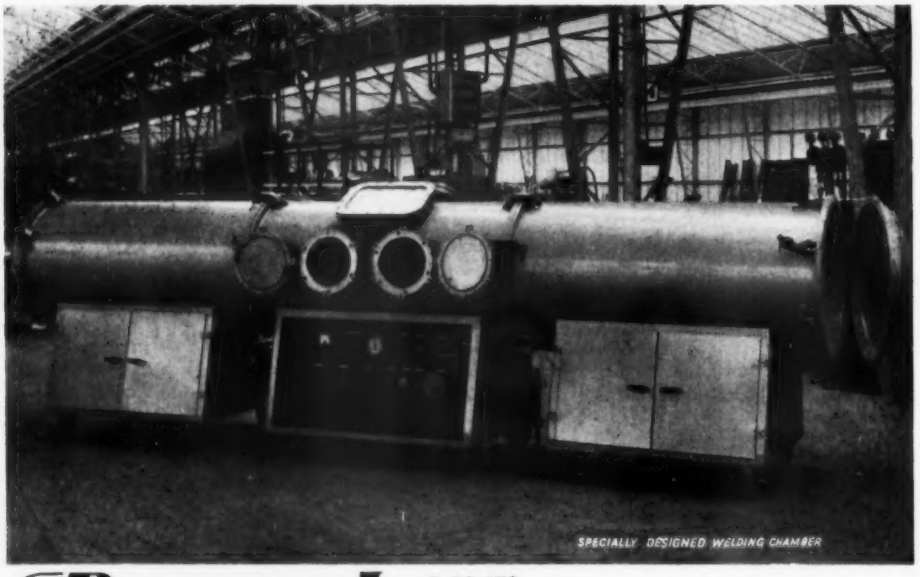
Vokes Genspring SUSPENSION SYSTEMS

VOKES GENSPRING LIMITED · GUILDFORD · SURREY

VG/30

Tick **No 107** on reply card for further details

fabricators in the rarer metals . . .


SPECIALLY DESIGNED WELDING CHAMBER

TITANIUM
ZIRCONIUM
HAFNIUM
MAGNESIUM ALLOYS
NIOBIUM ETC.

ALSO
NICKEL ALLOY STEELS

AND
STAINLESS STEELS

EST. 1844

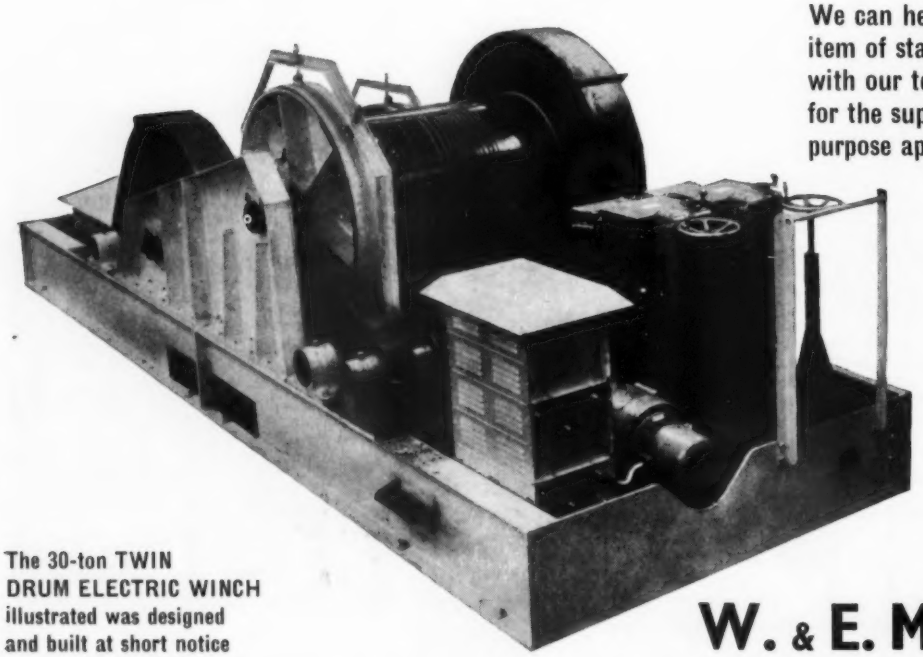
PHONE : 24228
28264 (5 LINES)
AND
ECKINGTON 551

J.R. Bramah & CO. LTD. OF Sheffield

DEVONSHIRE STREET · SHEFFIELD 3

Do you have Lifting Gear worries?

We can help you with any item of standard gear and with our technical facilities for the supply of special-purpose apparatus.



The 30-ton TWIN DRUM ELECTRIC WINCH illustrated was designed and built at short notice for use in Nuclear Power Station construction.

W. & E. MOORE LTD.

13/31 POPLAR HIGH ST., LONDON, E.14
EAST 2613-7: 4601-2 *Estab. 1863*

SERVICE DE RENSEIGNEMENTS POUR NOS LECTEURS

Il est souvent difficile au client publicitaire d'indiquer dans un espace restreint tous les détails de ses produits. Dans le cas où vous désireriez de plus amples renseignements à ce sujet, veuillez pointer le numéro approprié sur la carte ci-contre et envoyer cette dernière à NUCLEAR POWER.

AUSKUNFTSDIENST FÜR LESER

Es ist oft schwierig für Inserenten alle technischen Einzelheiten über ihre Produkte in einem begrenzten Platz zu bringen. Sollten Sie noch weitere Auskünfte wünschen, streichen Sie einfach die bestimmten Nummern auf der nebenstehenden Karte an, und senden Sie sie an NUCLEAR POWER.

SERVIZIO D'INFORMAZIONI PER I NOSTRI LETTORI

E' talvolta difficile all'inserzionista di indicare in uno spazio ristretto tutti i particolari dei suoi prodotti. Qualora desideraste ricevere più ampie informazioni a questo riguardo, favorite segnare il numero appropriato sul cartellino qui accanto ed inviare quest'ultimo a NUCLEAR POWER.

SERVICIO DE INFORMACIÓN PARA EL LECTOR

Se hace a menudo difícil para los anunciantes dar en un espacio limitado todos los detalles técnicos sobre sus productos. Si desea ulterior información, marque los números apropiados en la tarjeta opuesta y mándela a NUCLEAR POWER.

Информация для читателей

Часто бывает трудно рекламирующим лицам давать все технические подробности своей продукции в рекламе. Если Вам понадобятся добавочные сведения, то просто отметьте соответствующие номера на карточке на противоположной стороне и отправьте в NUCLEAR POWER.

請告詢問服務

在廣告上以有限的地方來解釋一些專門技術，及它們的功能，的確是有受限制的困難。若讀者欲要知道一些詳細的情形就請將可見的表格，取一號下來將閣下有疑問的項目，用筆勾一即寄給子能工程處即可。

読者サービス

廣告紙面の関係上製品の技術的細目は掲載しきれません。ので詳しくは裏のカードの適當なナンバーに印をつけて原子力宛投函して下さればお答へします。

Nuclear Power

REACTORS · MATERIALS · INSTRUMENTATION · PROCESSES · IRRADIATION

READER INFORMATION SERVICE № 14869

Advertisements

1	24	47	70	93	116	139	162	185
2	25	48	71	94	117	140	163	186
3	26	49	72	95	118	141	164	187
4	27	50	73	96	119	142	165	188
5	28	51	74	97	120	143	166	189
6	29	52	75	98	121	144	167	190
7	30	53	76	99	122	145	168	191
8	31	54	77	100	123	146	169	192
9	32	55	78	101	124	147	170	193
10	33	56	79	102	125	148	171	194
11	34	57	80	103	126	149	172	195
12	35	58	81	104	127	150	173	196
13	36	59	82	105	128	151	174	197
14	37	60	83	106	129	152	175	198
15	38	61	84	107	130	153	176	199
16	39	62	85	108	131	154	177	200
17	40	63	86	109	132	155	178	201
18	41	64	87	110	133	156	179	202
19	42	65	88	111	134	157	180	203
20	43	66	89	112	135	158	181	204
21	44	67	90	113	136	159	182	205
22	45	68	91	114	137	160	183	206
23	46	69	92	115	138	161	184	207

New Products and Tech. Literature

208	214	220	226	232	238	244	250	256
209	215	221	227	233	239	245	251	257
210	216	222	228	234	240	246	252	258
211	217	223	229	235	241	247	253	259
212	218	224	230	236	242	248	254	260
213	219	225	231	237	243	249	255	261

Books

262	264	266	268	270	272	274	276	278
263	265	267	269	271	273	275	277	279

If you would like further information about any advertisement or editorial item, simply tick the appropriate numbers on this card and mail to NUCLEAR POWER.

NAME

NAME OF BUSINESS

ADDRESS

POSITION HELD

NATURE OF BUSINESS

Nuclear Power

REACTORS · MATERIALS · INSTRUMENTATION · PROCESSES · IRRADIATION

READER INFORMATION SERVICE № 14869

Advertisements

1	24	47	70	93	116	139	162	185
2	25	48	71	94	117	140	163	186
3	26	49	72	95	118	141	164	187
4	27	50	73	96	119	142	165	188
5	28	51	74	97	120	143	166	189
6	29	52	75	98	121	144	167	190
7	30	53	76	99	122	145	168	191
8	31	54	77	100	123	146	169	192
9	32	55	78	101	124	147	170	193
10	33	56	79	102	125	148	171	194
11	34	57	80	103	126	149	172	195
12	35	58	81	104	127	150	173	196
13	36	59	82	105	128	151	174	197
14	37	60	83	106	129	152	175	198
15	38	61	84	107	130	153	176	199
16	39	62	85	108	131	154	177	200
17	40	63	86	109	132	155	178	201
18	41	64	87	110	133	156	179	202
19	42	65	88	111	134	157	180	203
20	43	66	89	112	135	158	181	204
21	44	67	90	113	136	159	182	205
22	45	68	91	114	137	160	183	206
23	46	69	92	115	138	161	184	207

New Products and Tech. Literature

208	214	220	226	232	238	244	250	256
209	215	221	227	233	239	245	251	257
210	216	222	228	234	240	246	252	258
211	217	223	229	235	241	247	253	259
212	218	224	230	236	242	248	254	260
213	219	225	231	237	243	249	255	261

Books

262	264	266	268	270	272	274	276	278
263	265	267	269	271	273	275	277	279

If you would like further information about any advertisement or editorial item, simply tick the appropriate numbers on this card and mail to NUCLEAR POWER.

NAME

NAME OF BUSINESS

ADDRESS

POSITION HELD

NATURE OF BUSINESS

Nuclear Power

REACTORS · MATERIALS · INSTRUMENTATION · PROCESSES · IRRADIATION

SUBSRCIPTION CARD № 14869

YES!

I want my own PERSONAL copy!

Please send me NUCLEAR POWER for 12 months/until countermanded:

U.K. **£2. 2s. 0d.**

U.S.A. and Canada **$8.00 + 50c.** postage

Other countries **£3. 3s. 0d.**

starting with the _____ issue

☐ Subscription enclosed

☐ Invoice me later

NAME _____

SEND TO MY HOME/BUSINESS ADDRESS _____

Postage will be paid by clear Power

No Postage stamp necessary if posted in Great Britain or Northern Ireland

Business Reply Folder Licence WD 1823

Nuclear Power,
Rowse Muir Publications Ltd,
3 Percy Street,
London, W1
England

Postage will be paid by clear Power

No Postage stamp necessary if posted in Great Britain or Northern Ireland

Business Reply Folder Licence WD 1823

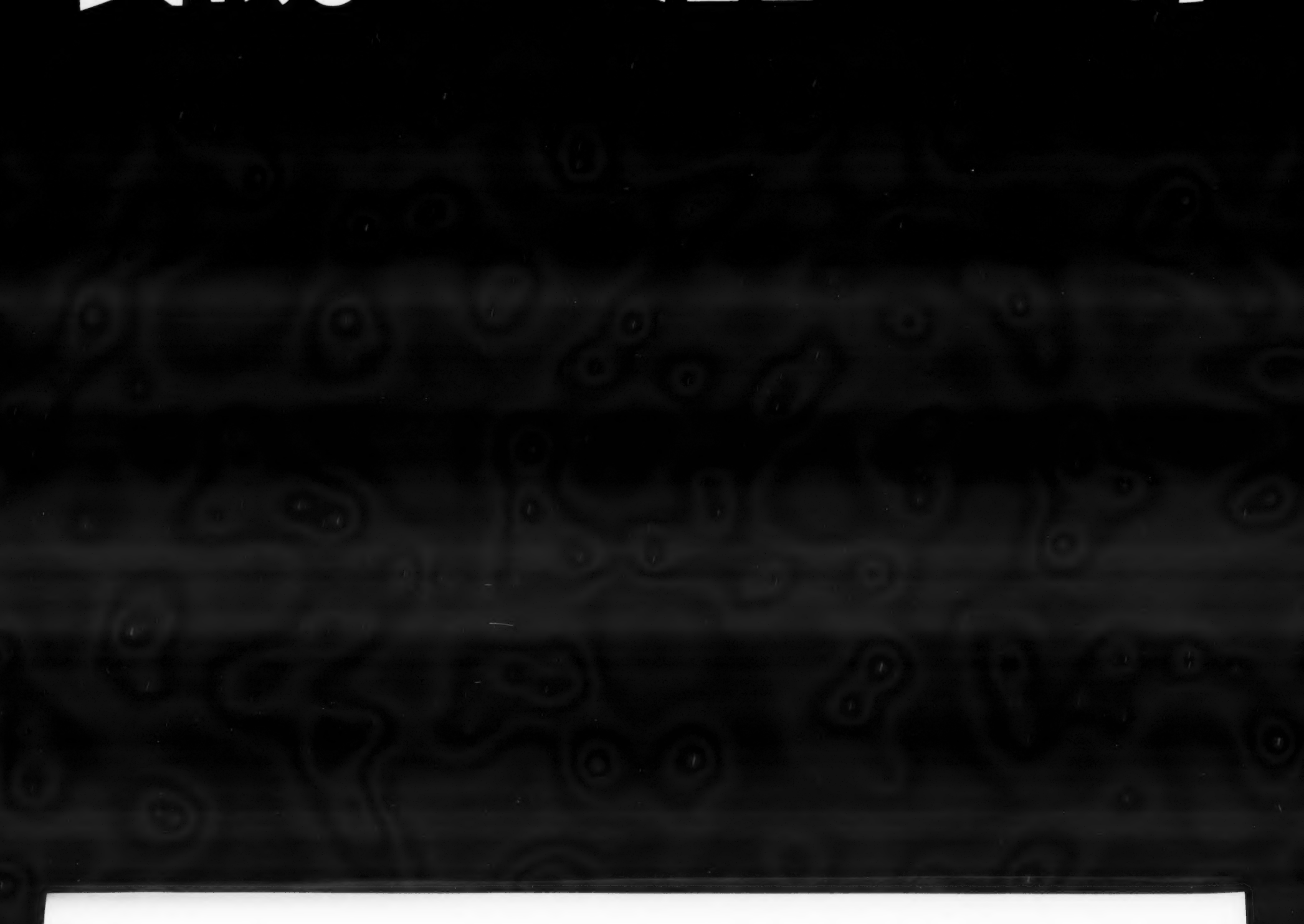
Nuclear Power,
Rowse Muir Publications Ltd,
3 Percy Street,
London, W1
England

Postage will be paid by Nuclear Power

No Postage stamp necessary if posted in Great Britain or Northern Ireland

Business Reply Folder Licence WD 1823

Nuclear Power,
Rowse Muir Publications Ltd,
3 Percy Street,
London, W1
England



Tick **No 109** on reply card for further details

COOL, CLEAN AIR *even in the most distressing climate*

B. O. MORRIS (HOLDINGS) LTD., *ANNOUNCE* that they are now producing Air Conditioning Equipment using the trade name of 'AIR KING'. This is the most efficient, easiest to instal and most attractive air conditioning unit for Offices, Hotels, Hospitals, Schools, Laboratories —in fact everywhere that cool, clean air is essential. Beautifully styled and superbly made.

Technical Agents are required in most territories throughout the World.

AirKing

AIR CONDITIONING UNIT

B. O. MORRIS LTD., MORRISFLEX WORKS, BRITON ROAD, COVENTRY. ENGLAND. Tel : 53333 (PBX)

Product of the Morrisflex *Group*

NUCLEAR REACTOR PHYSICS

an elementary course

by JAMES F. HILL B.Sc. principal, Reactor School A.E.R.E. Harwell

In response to widespread demands, we have reprinted the course in basic reactor physics which was specially written for NUCLEAR POWER and published in serial form during 1956 and 1957. The monograph has been revised by the author and forms an excellent introduction. (64 pp. in stiff boards.) Price : UK, 30s + 1s 3d Abroad $5 + 20c or equivalent

TO: ROWSE MUIR PUBLICATIONS LTD
3 PERCY ST, LONDON W 1.

Please send me_____ copy/s of Hill's REACTOR PHYSICS

☐ I enclose _____

☐ Please invoice me

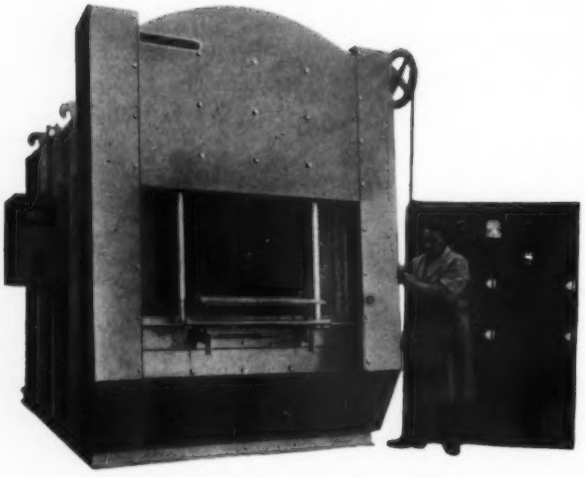
NAME _____

ADDRESS _____

Tick **No 110** on reply card for further details

Tick **No 111** on reply card for further details

A story to TELL!



A medium capacity heat-treatment furnace from the Barlow-Whitney range. Wide choice of standard models and, of course, custom-built units to order.

We mean a true story of course and one that if written fully would be far too long to read because it would cover a period of twenty-five years of intense activity, during which a wealth of experience and 'know-how' has been acquired about designing and building better equipment for all sorts of industrial heating applications for important concerns everywhere, and how this non-stop activity continues at an ever-increasing pace because today the name 'Barlow-Whitney' is the first choice, in the best circles, when it comes to—

Heat-treatment processing equipment of all kinds
OVENS AND FURNACES, VACUUM AND PRESSURE IMPREGNATION PLANTS, TROPICAL TESTING CHAMBERS, TINNING BATHS AND LEAD POTS, WAX AND COMPOUND KETTLES
and many other types of equipment, including of course
SPECIAL PROCESS PLANT TO MEET REQUIREMENTS
Write for further details quoting reference 16B

PROCESS HEATING Barlow-Whitney

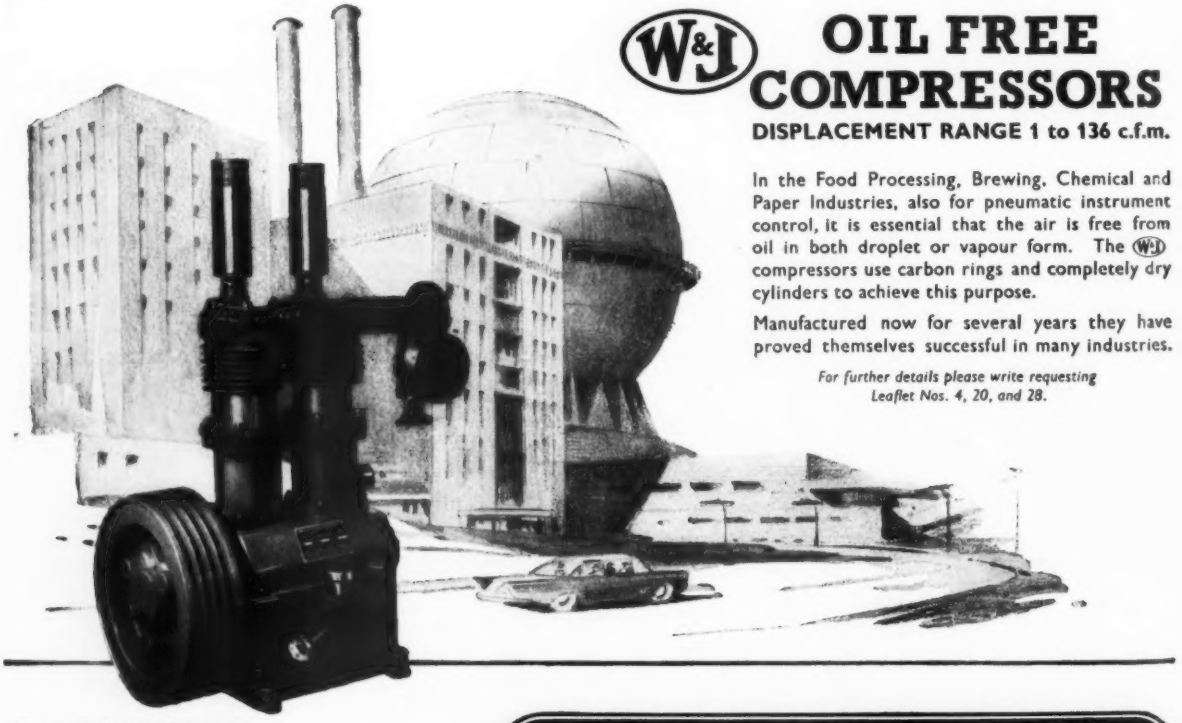
BARLOW-WHITNEY LTD., 2 Dorset Square, London, N.W.1 **Tel: AMBassador 5485-6** **Works, London & Bletchley**

BMJ

W&J

OIL FREE COMPRESSORS

DISPLACEMENT RANGE 1 to 136 c.f.m.



In the Food Processing, Brewing, Chemical and Paper Industries, also for pneumatic instrument control, it is essential that the air is free from oil in both droplet or vapour form. The W&J compressors use carbon rings and completely dry cylinders to achieve this purpose.

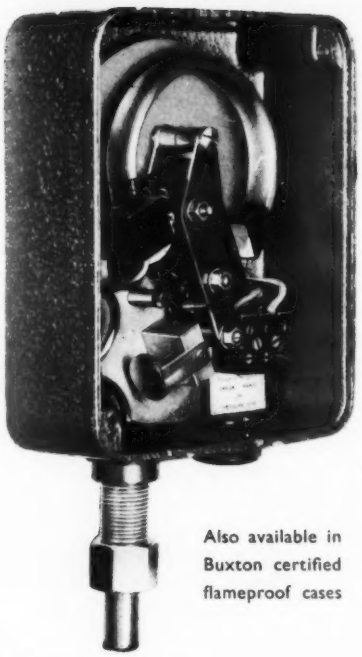
Manufactured now for several years they have proved themselves successful in many industries.

For further details please write requesting Leaflet Nos. 4, 20, and 28.

Illustrated is the twin cylinder model having a free air delivery of 50 c.f.m.

WILLIAMS & JAMES ENGINEERS LIMITED
GLOUCESTER · ENGLAND
TELEPHONE GLOUCESTER 24021-2-3 · TELEGRAMS & CABLES COMPRESSOR GLOUCESTER

Tick **No 113** on reply card for further details



Also available in Buxton certified flameproof cases

BOURDON PRESSURE SWITCH

For use with liquids or gases, and may also be supplied with Stainless Steel elements for corrosives. In ranges from 150 p.s.i. to 5,000 p.s.i. Contact rating 5 amps at 250 volts A.C.

In association with Stow and Partners Ltd.

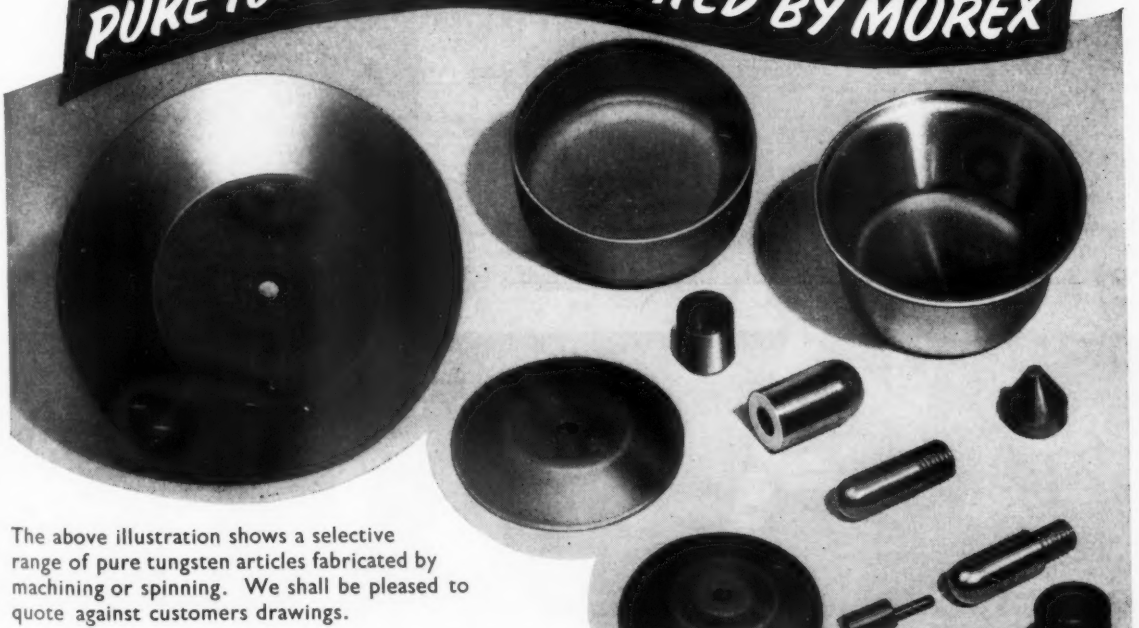
For full details, please write :

K.D.G. INSTRUMENTS LTD.

MANOR ROYAL, CRAWLEY, SUSSEX . Crawley 25151

London Showrooms, Service & Sales : 100 Fleet Street, E.C.4. Tel.: FLEet Street 5354/5

PURE TUNGSTEN FABRICATED BY MUREX



The above illustration shows a selective range of pure tungsten articles fabricated by machining or spinning. We shall be pleased to quote against customers drawings.

MUREX LIMITED *(Powder Metallurgy Division)*
RAINHAM • ESSEX *Telephone : Rainham, Essex 3322.*
Telex 28632. Telegrams : Murex, Rainham-Dagenham Telex
LONDON SALES OFFICE: CENTRAL HOUSE UPPER WOBURN PLACE, W.C.1.

Tick **No 114** on reply card for further details

Tick **No 115** on reply card for further details

AUTO-KLEAN

FILTERS ANYTHING THAT FLOWS

AUTO-KLEAN
Self-cleaning plate-type filters for all liquids handling flows up to 150,000 gallons per hour and providing positive defined mesh filtration with additional magnetic protection.

AUTO-KLEAN CIRCO
Self-cleaning strainers for water circulating systems handling flows up to 180,000 gallons per hour.

AUTO-KLEAN KOTON
Filters designed for depth filtration to defined micronic limits for all low viscosity liquids at flows up to 5,000 gallons per hour.

AUTO-KLEAN WYMESH
Special gauze filters for fine mesh protection at flows up to 42,000 gallons per hour.

AUTO-KLEAN LOLOS
Wire-wound filters for the protection of hydraulic systems at pressures up to 5,000 lbs. per square inch.

AUTO-KLEAN MICOM
Combined self-cleaning plate-type filter and paper filter giving both defined mesh and micronic protection for lubricating oil systems at flows up to 6,700 gallons per hour.

AUTO-KLEAN FLUSHFLO
Self-cleaning wire-wound filters for fully automatic protection of water and oil circulating systems at flows at up to 400,000 gallons per hour.

AUTO-KLEAN

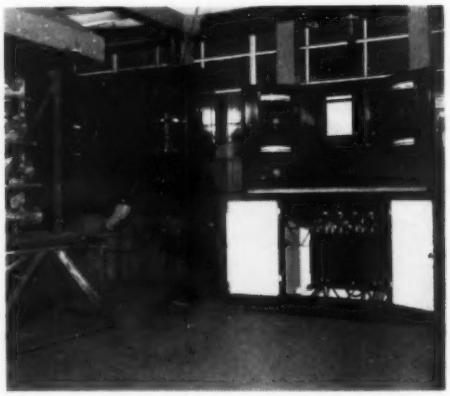
AUTO-KLEAN MICOM · AUTO-KLEAN FLUSHFLO · AUTO-KLEAN CIRCO
AUTO-KLEAN LOLOS · AUTO-KLEAN KOTON · AUTO-KLEAN WYMESH

AUTO-KLEAN STRAINERS LIMITED
ENGINEERS IN FILTRATION
LASCAR WORKS · HOUNSLOW · MIDDLESEX
Telephone: HOUnslow 7722 (10 lines)

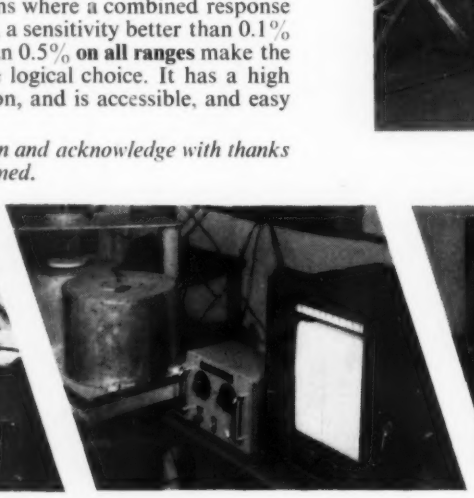
The diversity of users proves the versatility of

Cambridge **ELECTRONIC RECORDERS**

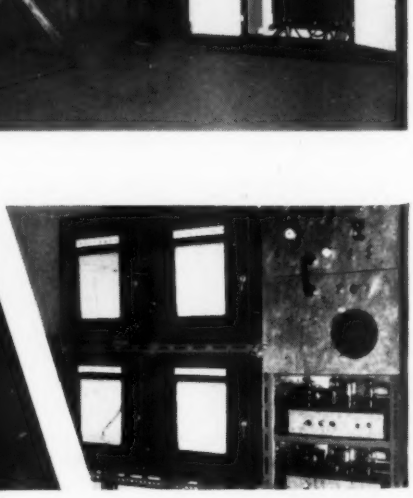
For sheer versatility, the Cambridge Electronic Recorder (and Recorder-Controller) cannot be equalled. Many firms in highly diverse industries have chosen it for its reliability, performance—and price, too. Among them is Murex Ltd., Rainham, Essex, to whom we are grateful for permission to publish the illustration on the right, which shows the In-Line Scanning (multi-point) version in use with a hundred thermocouples.
This is one of numerous applications where a combined response speed of better than 2 sec. full scale, a sensitivity better than 0.1% full scale and an accuracy better than 0.5% **on all ranges** make the Cambridge Electronic Recorder the logical choice. It has a high degree of component standardisation, and is accessible, and easy to maintain.
We illustrate below a further selection and acknowledge with thanks the courtesy of the organisations named.



Messrs. Hoover Ltd., Perivale, factory.



Messrs. Stewarts and Lloyds Ltd., Corby.



Dept. of Geology, Sheffield University

Send for List AP/186. For future publications, write for Mailing Form AP/3/59.

CAMBRIDGE INSTRUMENT CO. LTD. 13 GROSVENOR PLACE, LONDON, S.W.1.

Tick **No 117** on reply card for further details

NON FERROUS METALS

For the most comprehensive stock available

BRASS, COPPER, PHOSPHOR BRONZE, GUN METAL, NICKEL SILVER
ALUMINIUM, DURALUMIN, TIN PLATES, ZINC SHEETS
TEE RODS, TUBES, STRIPS, SHEETS, BLANKS, ANGLES, CHANNELS
RIVETS, SCREWS, NUTS, WASHERS, GAUZE, SOLDER
PERFORATED SHEETS, STUDDING

J. SMITH & SONS (CLERKENWELL) LTD.
42/54, ST. JOHN'S SQUARE, CLERKENWELL, LONDON, E.C.1
phone: CLE 1277 (14 lines)
Screw Dept: CLE 0925

a Complete Scintillation Service

phosphors and counters

PLASTIC & LIQUID PHOSPHORS

★ PLASTIC PHOSPHOR NE 102, light output 65% anthracene, available in all sizes and shapes up to one ton, in thin sheet form, in fine tubes for the construction of scintillation flow counters, or as filaments for the construction of scintillation nuclear track chambers (Bulletin 11).

★ BORON POLYESTER PLASTIC PHOSPHOR NE 400 and NE 401 (88% B^{10}) for neutron detection. Standard sizes from 0.5 to 5.0 inches diameter (Bulletin 13).

★ LOADED LIQUID SCINTILLATORS in bulk or encapsulated, containing Pb for extreme X-ray sensitivity, and Gd, B, Cd, and Sm for neutron detection (Bulletins 9 and 9a).

★ SCINTILLATING GELS for efficient internal counting of suspended materials (Bulletin 9).

★ SCINTILLATION CHEMICALS of highest purity P.B.D., POPOP, T.P.B., p-terphenyl, PPO, D.P.H., alpha-N.P.O., D.M.C., B.B.O., B.P.O., D.P.A., D.P.S., vinyltoluene, styrene, xylene, toluene, methyl borate, phenylcyclohexane, monoisopropylbiphenyl.

★ LIGHT PIPES of polyvinyltoluene and polystyrene.

★ PLASTIC PHOSPHOR SPIRAL FLOW CELL NE 801 for beta and alpha emitters.

Nuclear Enterprises (G.B.) Ltd

NEW LINE OF PRECISION NUCLEAR INSTRUMENTS

★ Non-overloading Linear Pulse Amplifier NE 5202 of the Fairstein type (Bulletin 14)
★ Pre-Amplifier and Cathode Follower NE 5202A
★ Single Channel Pulse Height Selectors NE 5102 and NE 5103
★ Shielded Scintillation Head Units NE 5501-3
★ Highly Stabilised EHT Supplies NE 5302 (1.8 kV) and NE 5303 (5 kV)
★ Complete assembly for C14 and tritium counting NE 8301
★ Complete Human Body Counter Installations NE 8101-3
★ Ratemeter NE 5401 with eight ranges and six time constants
★ Scanning scintillation spectrometer NE 8601

BANKHEAD MEDWAY, SIGHTHILL, EDINBURGH, 11.
SCOTLAND, TEL: CRA 4513

OF SPECIAL NOTE

★ SCINTILLATION CRYSTALS by Harshaw. Exclusive concessionaire in Great Britain for NaI(Tl), CsI(Tl), LiI(Eu), and Li^6I(Eu). NaI(Tl) available in sizes up to 9" diameter x 9" thick, and down to 0.015" thick with 0.005" Be windows for X-ray counting and spectrometry. Resolution with standard sizes 7-8% on Cs^{137} line. CsI(Tl) down to 0.005" thick for alpha and proton studies. Li^6I(Eu) in special low temperature mounts for fast neutron spectrometry.
★ NEW ! Photomultiplier—NaI(T1) combinations with direct coupling of crystal to photomultiplier and giving improved resolution.
★ C.D.C. 100-CHANNEL TRANSISTORISED KICKSORTER at a new *low* price for 1959 and with short delivery. Full range of accessories to provide automated assembly.
★ MULTI-CHANNEL SCINTILLATION SPECTROMETER NE 8201 for industrial tracer investigations (Bulletin 15).

Write now for Bulletins and Price List

ndk 707

Tick **No 118** on reply card for further details

Tick **No 119** on reply card for further details

WELDING CHARGE TUBES

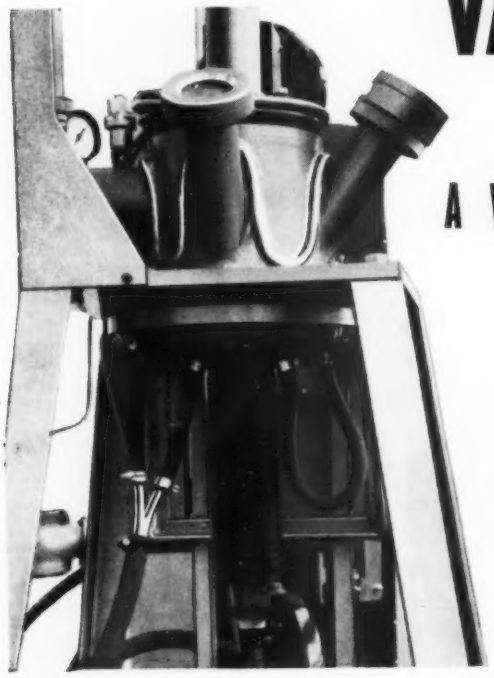
The Unit Superheater and Pipe Co. Ltd., following initial contracts for reactor charge tubes for Calder Hall and Chapelcross power stations, has been entrusted by Whessoe Limited, member company of the Nuclear Power Plant Co., to produce the charge/discharge and control rod stand tubes for Bradwell Power Station.

The photograph shows an operator welding one of the 448 charge tubes, using low hydrogen electrodes throughout.

THE **UNIT** SUPERHEATER AND PIPE CO. LTD · UNIT WORKS
SWANSEA Telephone : Swansea 54091 (6 lines). Telegrams : 'Superunits', Swansea. Telex: 48-208.

UNIT

VACUUM ARC MELTING



A Versatile Furnace For PURE MELTING

The "Speedivac" arc melting furnace provides the research metallurgist with a means of melting metals by both the consumable and non-consumable electrode techniques. Using the former method such metals as copper and steel can be produced in pure ingot form and it is particularly useful for reactive metals such as titanium and zirconium. The non-consumable electrode assembly enables even the most refractory metals to be melted and alloyed at temperatures of up to 4,000°C. The pumping system includes "Speedivac" high speed booster vapour pumps for the rapid removal of gases and vapours.

FULL DETAILS ON REQUEST

EDWARDS HIGH VACUUM LTD MANOR ROYAL · CRAWLEY · SUSSEX · Crawley 1500

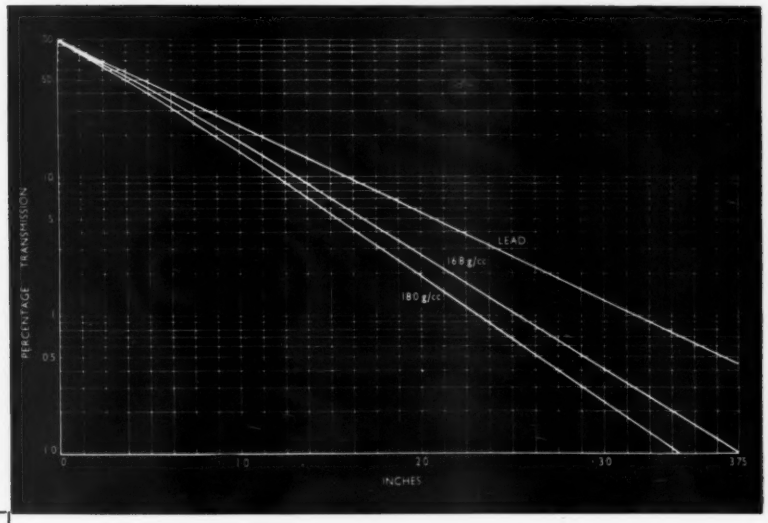
Tick **No 121** on reply card for further details

G.E.C.

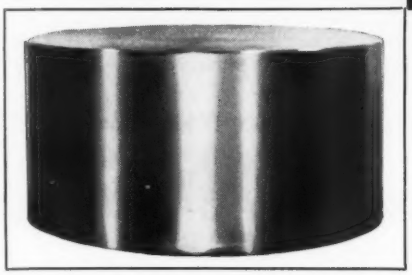
HEAVY ALLOY

supplied in densities
16.8,17.0,17.5,18.0g/cc(nominal)

- ***for screening purposes***
- ***for balanced weights***



Broad beam absorbtion of Gamma-radiation from COBALT-60. Density: 16·8 g/cc. and 18·0 g/cc.



The above piece of G.E.C. Heavy Alloy was made for the United Kingdom Atomic Energy Authority. It weighs 660 lb.

THE GENERAL ELECTRIC CO. LTD., Component Sales Dept., Osram Metals, East Lane, Wembley, Middlesex. Arnold 4321

WHERE ONLY THE BEST IS GOOD ENOUGH

UKAEA
BRADWELL
BERKELEY
HUNTERSTON
HINKLEY POINT
MARCOULE
A. S. E. A. (SWEDEN)
AGIP NUCLEARE (ITALY)
CERN (SWITZERLAND)
DANISH A.E.C.

NUCLEAR INSTRUMENTATION

BY

"GR"

IS

THE EQUIPMENT OF CHOICE

NUCLEAR INSTRUMENTATION OF ALL TYPES

GENERAL RADIOLOGICAL LTD.

Nuclear Engineering Division

15-18 CLIPSTONE STREET, LONDON, W.1

REMOTE HANDLING AND SHIELDING

Tick **No 122** on reply card for further details

Tick **No 123** on reply card for further details

ATLAS

STEEL CASTINGS

For Internal Pressure Work

Turbine Castings, Steam Chests, Valves, etc. in carbon and alloy steels up to 9 tons weight and to any specification.

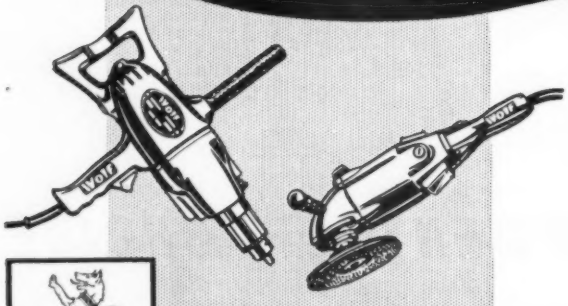
ON ADMIRALTY, WAR OFFICE, LLOYD'S and other LISTS

THE ATLAS STEEL FOUNDRY & ENGINEERING COMPANY, LIMITED

ATLAS STEEL WORKS: ARMADALE, WEST LOTHIAN, SCOTLAND

Telegrams: "ATLAS ARMADALE WEST LOTHIAN" Telephone No.: Armadale 323

"Wolf the work"



with Wolf Electric Tools

ELECTRIC DRILLS · GRINDERS · POLISHERS
SANDERS · SAWS · BLOWER · HAMMER
NUTSETTER · SCREWDRIVERS
COMBINED MORTISER & DRILL
ENGINEERING RECONDITIONING EQUIPMENT, etc.

Full details of all Wolf Electric Tools on request from:

Wolf ELECTRIC TOOLS

WOLF ELECTRIC TOOLS LTD · HANGER LANE · LONDON W.5 Tel: PERivale 5631-4

Branches: BIRMINGHAM · BRISTOL · GLASGOW · LEEDS
MANCHESTER · NEWCASTLE Agents throughout the World

Tick **No 125** on reply card for further details

KIRKS

Flanges and Malleable Fittings encircle the World

Our flanges, pipework and malleable fittings are in use all over the Globe.

KIRK & CO. (TUBES) LTD.

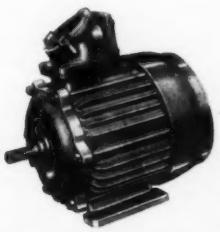
74/82 PARADISE STREET
LONDON, S.E.16. Bermondsey 3156/7/8
also at WALSALL · MANCHESTER · PONTYCLUN

K
the heart of reliability

BUY BRITISH—BUY KIRKS

No need for panic

No need to feel you are sitting on a powder barrel when you have EPE Flameproof electric motors—Buxton certified, of course. We have an enviable reputation for building reliable motors, standard or special, which are completely safe. And we build them at a price which will delight you. May we send you details?



E·P·E

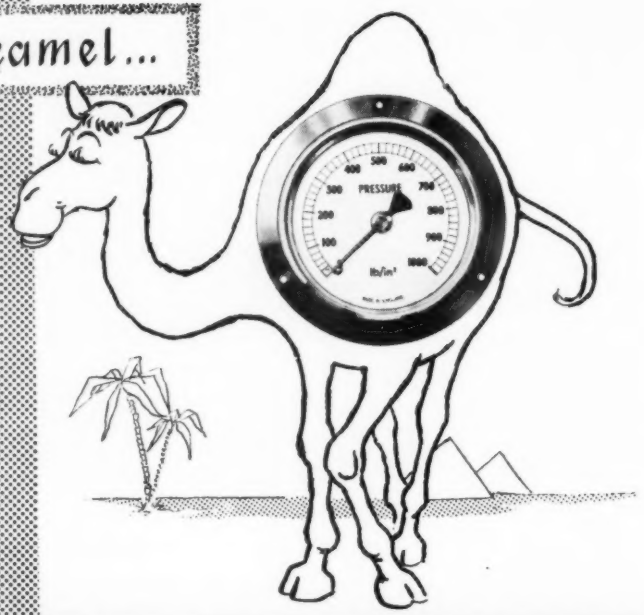
THE ELECTRICAL POWER ENGINEERING CO. (B'HAM) LTD.
Bromford Lane **Birmingham 8**
Telephone: STEchford 2261 **'Grams: Torque 'Phone Birmingham**
LONDON OFFICE: 421 Grand Buildings, Trafalgar Sq., London, W.C.2
Telephone: Whitehall 5643 & 7963

Tick **No 126** on reply card for further details

Tick **No 127** on reply card for further details

You can't gauge a camel...

. . . by it's hump—or from the expression on it's face for that matter. But one glance at a P. & G. pressure gauge reveals an instrument of quality, made by craftsmen to ensure accuracy and dependability for a very long time. This is no mirage—see one for yourself. The range of P. & G. pressure gauges includes many different types to suit most applications—vacuum, combined, altitude, electric contact, differential, critical, duplex diaphragm, capsule etc.
Write for publication No. 87



WINDMILL

Payne & Griffiths Ltd

TUDOR WORKS · WINDMILL LANE
SMETHWICK · BIRMINGHAM

ELECTRO-HYDRAULICS LIMITED

An expanding Company with first class design team and research laboratories ; extensive modern manufacturing facilities and a world wide sales and service organisation.

These facilities are available for either :–

Design
Development
Manufacture or
Sales and Service

High quality Mechanical, Hydraulic and Electric equipment, automatic control systems and special purpose machinery in the field of automation and consideration of manufacture under license of any Engineering Products.

Electro-Hydraulics Limited
Liverpool Road, Warrington, Lancashire

MEMBER OF THE OWEN ORGANISATION

Tick No 129 on reply card for further details

By the selection of a suitable grade from our range of porous ceramic media, Aerox Filter Units will effectively withhold all solid particles of a given micron size, down to sub micron sizes, and also remove the gross oil and moisture contamination which is often evident in compressed service lines. Their resistance to thermal change and chemical action make them especially suitable for the filtration of CO_2 gas.
Find out more about the range of Aerox Filter Units. Please write for literature.

AEROX

FILTER UNITS

AEROX LIMITED *Leaders in a specialised field*

Ceramic Works, Hillington, Glasgow SW2
Telephone: HALfway 4615/6

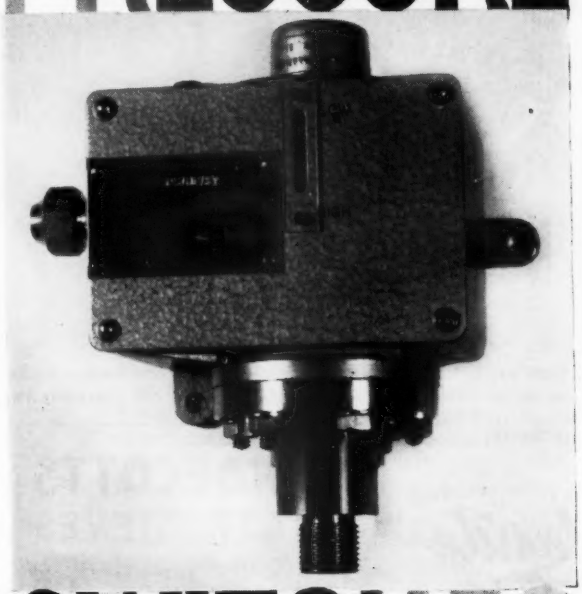
Engineering Works, Crompton Way, Crawley, Sussex,
Telephone: Crawley 25077

Tick No 130 on reply card for further details

LONDEX

STAINLESS STEEL

PRESSURE SWITCHES



List available No. 119, 14 pages

Now for the first time a complete range of pressure switches for working with *corrosive* gases and liquids.

Ranges cover operating pressures from 5-1000 lbs. p.s.i.

All parts in contact with operating liquid or gas are manufactured from *stainless steel*.

These switches are of special interest to (control) engineers in Chemical and Nuclear establishments. Interest extends to food and other processing industries.

These switches are in addition to the large number of different types already made.

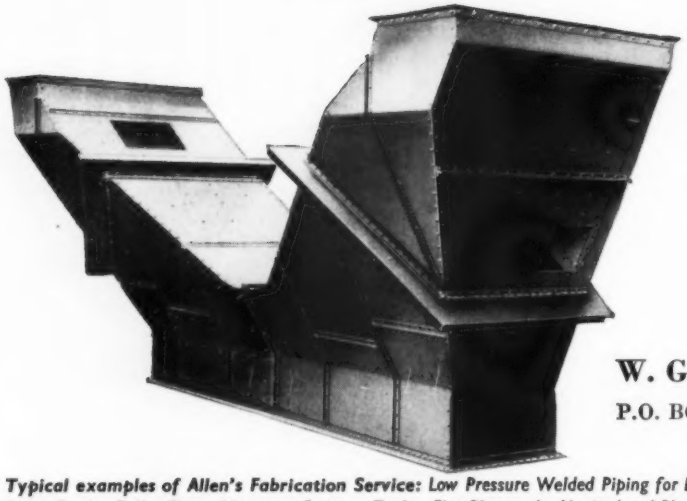
LONDEX LTD.

ANERLEY WORKS · LONDON · S.E.20
SYDENHAM 3111 (5 lines)

TA2104

Tick **No 131** on reply card for further details

Fabricated Platework to your specification



We specialise in welded or riveted fabrications in Mild Steel, Stainless Steel and Aluminium Alloys and pride ourselves on the attention paid to constructional details which ensure trouble-free service for the finished product.

A typical example of our craftsmanship is the fabrication of Ducts of rectangular design for Power Stations or Boiler Houses. They are accurately fabricated to suit your requirements.

Our "FABRICATED PLATEWORK" Brochure fully describes our Service and is available on application.

W. G. ALLEN & SONS (TIPTON) LTD.

P.O. BOX 4 · TIPTON · STAFFS

Tel: TIPTON 1266

Typical examples of Allen's Fabrication Service: *Low Pressure Welded Piping for Exhaust Steam, Gases, Water, etc. Pipes and Ducts for Super Power Station Boiler Plant; Hoppers; Casings; Tanks; Flat Platework; Manipulated Platework of all kinds; Bed Plates and Frames for Machines, etc.*

Tick **No 132** on reply card for further details

Inside Story

ENDECOTTS TEST SIEVES

No Crevices to trap particles, frame and wire cloth are joined as one.

Guaranteed Accurate — Manufactured under licence from the British Standards Institution.

Mechanical Sieving is ideal with Endecotts Sieves—several simultaneous tests are possible with intermediate receiving pans.

British, U.S. Standards and Tyler Equivalents are readily available, many other international standards also supplied.

"ENDROCK" TEST SIEVE SHAKER

saves valuable time and effort of skilled personnel, similar to manual motion but is more consistent having a regular mechanical action—a time switch controls the length of time for tests.

We operate a **Recovering Service**—if sieving is important to your business, ring or write for literature —or for any advice you require—we'll be glad to help.

ENDECOTTS (FILTERS) LTD

Lombard Road · London, S.W.19

Telephone: LIBerty 8121/2 · Telegrams: ENDFILT, LONDON

Tick **No 133** on reply card for further details

Fabricated by

YARROW

. . . the bodies for twelve 60" Tansphere Valves being supplied by Hopkinsons Ltd for Bradwell-on-Sea Nuclear Power Station

YARROW & CO. LTD

SCOTSTOUN, GLASGOW, W4

SCOTLAND

Tick **No 134** on reply card for further details

PUMPS

CENTRIFUGAL	RECIPROCATING
Split-casing.	**Bucket** Pumps.
Single and Multi-stage.	Double and Quadruple Acting.
Non-clogg.	**Triplex Ram** Pumps.
Slurries and Solids.	**Steam** Pumps.
Vertical **Sump** Pumps.	Direct Acting and Duplex.

HAND PUMPS of all types.

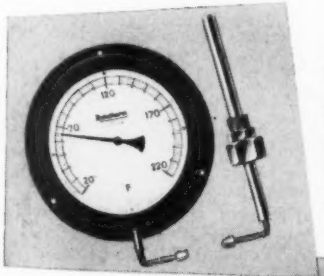
You are invited to visit us on our Stand (No. 2, Row N, Ground Floor, National Hall) at the Engineering, Marine, Welding and Nuclear Energy Exhibition, to be held at Olympia.

LEE, HOWL & CO., LTD.
TIPTON, STAFFS.

Tick **No 135** on reply card for further details

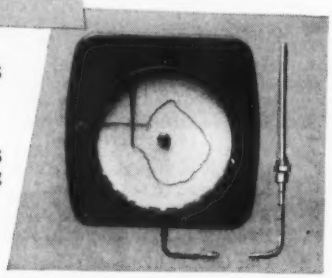
Rototherm

MERCURY-IN-STEEL TEMPERATURE INSTRUMENTS



DIAL THERMOMETERS for Industrial purposes.
DIAL THERMOMETERS for Diesel engine use.
INDICATOR CONTROL THERMOMETERS with Electric Contact Head.
MAX. or MIN. INDICATORS.

TEMPERATURE RECORDERS
Single or Dual Pen.
Fixed or Portable Models.
TEMPERATURE CONTROLLERS
Indicating and Non-Indicating



VISIT STAND No. 14 at the E.M.W. & N.E. Exhibition, Olympia 16-30 April, 1959

Also a full range of BI-METAL and VAPOUR PRESSURE Temperature Instruments.
Write for details

THE BRITISH ROTOTHERM CO. LTD.
Merton Abbey, London, S.W.19. Telephone: LIBerty 7661 (6 lines)

Tick **No 136** on reply card for further details

The recognised authorities on every aspect of magnesium technology, MEL are constantly evolving new alloys and improving existing ones.

Magnox you know about. MEL are approved suppliers of this important canning material for the UKAEA. In collaboration with UKAEA and the industrial consortia they are contributing their considerable research acumen to the further development of magnesium alloys, specifically designed for nuclear work.

The skill and experience of MEL are available to all who wish to exploit the special advantages of the latest magnesium alloys in nuclear engineering projects.

MEL

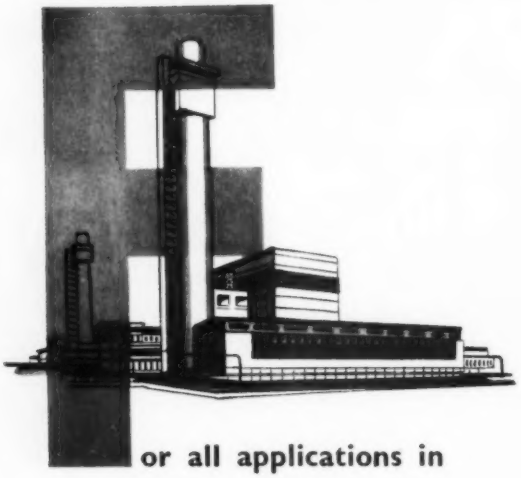
MAGNESIUM ELEKTRON LTD

Clifton Junction Manchester
Swinton 2511

London Office: 5 Charles II Street St. James's SW1
Trafalgar 1646

Magnesium Elektron, Inc., New York 20, USA

Tick **No 137** on reply card for further details



or all applications in Nuclear Power plants . . . . . continue to fit

FREMO STAINLESS STEEL

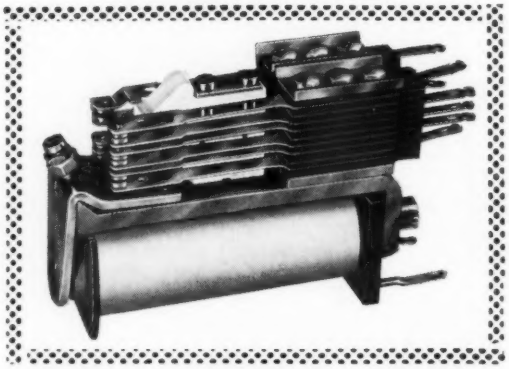
bolts, nuts, screws and other fasteners with corrosion, contamination and heat resistant properties.

FREMO
TRADE MARK

FREDERICK MOUNTFORD
(BIRMINGHAM) **LIMITED**
Fremo Works, Moseley St., Birmingham, 5
Tel. MIDland 7984 PBX
Grams 'FREMO' Birmingham

Tick **No 138** on reply card for further details

RELAYS
TO SPECIFICATION

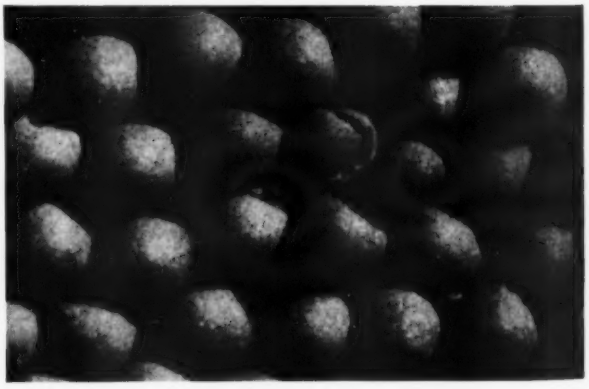


POST OFFICE TYPE
3,000 and 600 RELAYS
Specialists in tropical and Services jungle finish.
Guaranteed to full A.I.D. and I.E.M.E. standards.
Prompt Deliveries Prototypes within 24 hours.
Post Office approved. All relays guaranteed made in our own works.
P.T.F.E. insulation now available.

SIMMONDS
Manufacturers to H.M. Government Departments and leading Contractors
L. E. SIMMONDS LIMITED, 5 BYRON ROAD, HARROW, MIDDX.
TELEPHONE: HARROW 7797/9 TELEGRAMS: SIMRELAY HARROW

Tick **No 139** on reply card for further details

Are you sure . . .



that this picture shows a clutch of turtles' eggs? Maybe you're not too sure.*

But one thing you can be sure about—the Suffolk Iron Foundry has the answer to your welding problem.

Our team of highly-qualified technicians is always available. With their fleet of vans specially equipped with the latest oxy-acetylene apparatus they can solve any problem on the spot. All you have to do is ring Stowmarket 183.

* (*The "eggs" are really the heads of matches.*)

SUFFOLK IRON FOUNDRY (1920) LIMITED, STOWMARKET, SUFFOLK

Tick **No 140** on reply card for further details

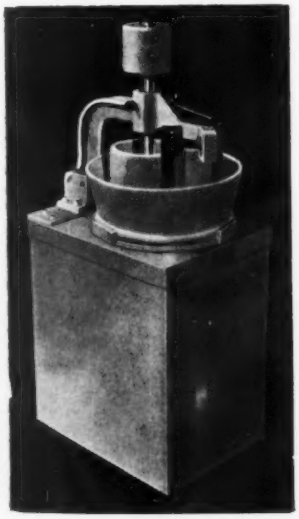
FOR GEARS AND GEAR UNITS OF EVERY DESCRIPTION

Specify **HIGEARS**

We have a technical representative or agent in your area backed up by a competent technical staff to give you expert advice. Call us in early in the design stage. We may be able to reduce the cost by advising one of our standard gear units.

HIGHFIELD GEAR & ENGINEERING CO. LTD.,
NILE STREET · HUDDERSFIELD · YORKSHIRE
Telephone : **Huddersfield 4490 1/2** *Telegrams :* **Higears**

Tick **No 141** on reply card for further details



laboratory end runner mills

Available with four mortar sizes, 7", 10", 15", 20". Mill supplied complete with electric motor and starter and with either ceramic or metal mortar and pestle.

The mortars and pestles are interchangeable. A ceramic set can be used to process material adversely affected by contact with metal and a metal set, either high grade cast iron or stainless iron can be carried as a spare set for use on material for which ceramic is unsuitable. The pestles are arranged to swing clear of or lift out of the mortars to facilitate emptying or cleaning.

The model illustrated is the No.2 mill with a 15" diameter mortar

PASCALL

Write or telephone Crawley 25166 for List EN 3204.

THE PASCALL ENGINEERING CO. LTD.
GATWICK ROAD · CRAWLEY · SUSSEX.

Tick **No 142** on reply card for further details

Production British, Service International

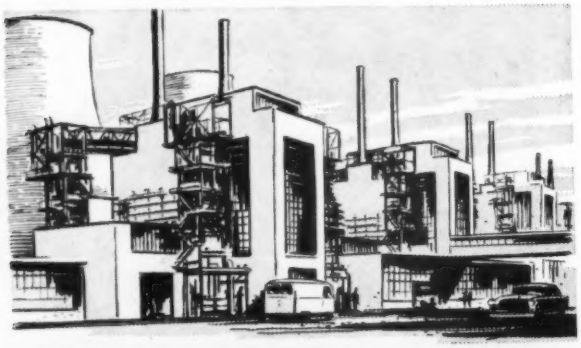
West Instrument Ltd. provide a range of temperature controllers and recorders, produced in Britain for international markets in the plastics, metal, nuclear, ceramic, chemical and process industries. An efficient after-sales service is backed by speedy supply of spare parts by West representatives in major cities throughout the world. In this way West instruments, fitted to exported machinery, are assured efficient maintenance.
West instruments are proving themselves invaluable in countries as far apart as Holland and Hong Kong, India and Italy, New Zealand and Norway, South Africa and Sweden. Full details of equipment and services from:

WEST *Instrument*
LIMITED

52 Regent Street,
Brighton, Sussex. Telephone: 28106

Associate of the West Instrument Corporation of Chicago U.S.A.

Tick **No 143** on reply card for further details



To be sure...

Since 1750 GRAZEBROOK have served Industry and have been in the forefront of Industrial development. Today the company is equipped to meet the most exacting demands of modern industry and we invite you to contact us with YOUR particular production problems.

GRAZEBROOK

LEAD SHIELDING

REACTOR TANKS

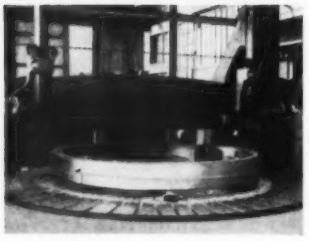
PRESSURE VESSELS
(STAINLESS STEEL AND ALUMINIUM)

CHEMICAL VESSELS • CALANDRIAS

can make it!

HEAVY MACHINING FACILITIES

Plant and Machinery manufactured to customers' design, including the Chemical, Steel, Plastic and Rubber Industries.



•

GREY IRON CASTINGS UP TO 20 TONS

M. & W. GRAZEBROOK LTD

HEAVY ENGINEERS & IRON FOUNDERS

DUDLEY - WORCS

Telephone: DUDLEY 2431-3 *Telegrams: Grazebrook, Dudley*

Tick **No 144** on reply card for further details

STEEL FABRICATING AND MACHINING SPECIALISTS

LLOYD'S CLASS II FUSION WELDED VESSELS
CONTRACT GUILLOTINING—96" × ⅛"
HYDRAULIC FORMING & BENDING—150 TONS
PLATE ROLLING—120" × ⅛"
PROFILE CUTTING UP TO 6" THICK
ARC & GAS WELDING

•

MACHINING CAPACITY
UP TO 86" DIAMETER & 144" LENGTH

•

OIL, WATER & ACID STORAGE TANKS
Ex-Works & Fabricated on Site

•

EXPERIMENTAL & RESEARCH CHAMBERS
VACUUM VESSELS, PROCESSING & STORAGE
TANKS, DUCTING, PIPEWORK
CHIMNEYS, HANDLING EQUIPMENT
HEAT EXCHANGERS & STRUCTURES

•

Enquiries invited

C.F.IDE ENGINEERING LTD.

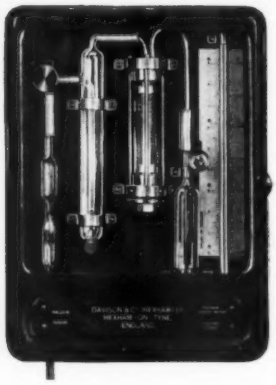
EMPIRE WORKS
163 CLARENCE STREET
KINGSTON-UPON-THAMES

Phone Kingston 6820 & 6272

Tick **No 145** on reply card for further details

THE "DAVISON" VACUMETER

A Mercury Column Vacuum Gauge for accurately registering the absolute pressure within a Steam Condenser



★ Standard Vacuum Gauges in Central Electricity Generating Board Power Stations.

★ Exported throughout the world and used on Turbine-driven Steamships.

DAVISON & CO. (HEXHAM) LTD.
(ENGINEERS)

HEXHAM-ON-TYNE **ENGLAND**

Telegrams: **" Davison, Hexham."** *Telephone:* **Hexham 7**

Tick **No 146** on reply card for further details

A.I.D. A.R.B.

WHAT ARE **YOU** LOOKING FOR?

CONTROL VALVES!

GAS BOXES!

HYDRAULIC MECHANISMS!

We cover all fields from small CONTROL VALVES to COMPLEX FABRICATION for HIGH VACUUM WORK to intricate HYDRAULIC MECHANISMS with delicate instrument like sub-assemblies.

Facilities exist for: Ideally clean assembly to U.K.A.E.A. requirements—deep freeze testing to —50°C also for design and development of equipment for your special needs.

SANDALL PRECISION CO. LTD.

WATLING STREET, BLETCHLEY, BUCKS

Tel: 3456-8 PBX *Grams: SANDALL BUCKS*

Tick **No 147** on reply card for further details

BARKER STEEL ROLLING DOORS *WITH FLAT LATHS*

Barker Steel Rolling Doors gain considerable strength from their flat lath design, the endlocks on alternate laths making the door secure and rigid. The flat laths are of steel, and are identical, replaceable or interchangeable in case of damage. They are rugged, neat — prime painted, sherardized or galvanised as required — and can be fitted to the widest openings.

ALSO AVAILABLE WITH CONVENTIONAL CURVED LATHS

Write for fully informative literature to Dept. A7

JOHN BARKER & SONS (ENGINEERS) LTD.

Union Street, Ancoats, Manchester 4. Telephone: COLlyhurst 2018

London: Beacon Works, Strawberry Vale, Twickenham. Tel: POPesgrove 0794

SCOTLAND: W. J. Leonard, 51 Braemar Place, Aberdeen

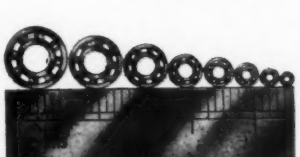
Tick **No 148** on reply card for further details

LADY Hercules!

Who would think a ladybird could carry 15 times its own weight. This one is doing it easily and happily.* The load is a 4 m.m. Hoffmann Miniature Ball Bearing. Even more startling is the fact that this bearing can carry 16,000 times its own weight, viz., 4 lbs. at 100 r.p.m. A range of Hoffmann Miniature Ball Bearings is made from ½" down to 3 m.m. outside diameter, to B.S.I. limits, or if required, to specifications A B E C 3, 5 or 7.

HOFFMANN

THE GREAT LITTLE BEARINGS



*After the photograph was taken the ladybird flew away home.

THE HOFFMANN MANUFACTURING CO. LTD
CHELMSFORD ESSEX

CLASSIFIED ADVERTISEMENTS

DISPLAY ANNOUNCEMENT RATES :— 1 insertion 40/- per single col. inch
6 insertions 38/- per single col. inch
12 insertions 36/- per single col. inch

LINEAGE ANNOUNCEMENT RATES :— 4/- per line. 5% discount 6 insertions, 10% discount 12 insertions

BOX Nos. :— 1/- extra will be charged

COPY DATE :— Advertisements for May issue to be received not later than April 13.

SITUATIONS VACANT

THE NUCLEAR POWER PLANT COMPANY LIMITED
requires
a
CHIEF CONSTRUCTIONAL ENGINEER

This is a new and senior appointment which gives opportunities for further promotion.

The successful candidate will be responsible for the planning and construction of the Company's nuclear power stations in the United Kingdom and abroad.

Applicants should have considerable experience in both the planning and erection of power stations and some design experience would be preferable.

The appointment is pensionable and the Company is prepared to take into account any accrued pension rights of the successful applicant when making the appointment.

Suitably qualified engineers are invited to write, giving full details of experience and qualifications to the

General Manager,
The Nuclear Power Plant Co. Ltd.,
Booths Hall,
Knutsford,
Cheshire

All applications will be treated in confidence and should be marked PRIVATE AND CONFIDENTIAL, quoting reference NP/CE/65.

ASSISTANT
INSTRUMENT ENGINEER
for
CHAPELCROSS
NUCLEAR POWER
STATION

to work in the Instrument Department, which is responsible for installation, servicing and testing of all Works instrumentation including nuclear, electronic, physical, electrical, pneumatic, health physics and industrial television equipment.

This is an opportunity for an engineer to gain experience of reactor and associated power plant instrumentation and control. He will be responsible to the Instrument Engineer for:—liaison with the Reactor Operations and Technical Department during reactor start-up tests and for subsequent instrumentation tests and experiments, organisation and co-ordination of a planned maintenance system, investigation of operational and servicing problems on instrumentation and other duties which may include responsibility for the acceptance of instrument installations from the Consultant Engineers and installation and calibration tests.

A recognised engineering apprenticeship or comparable training and corporate membership of a senior engineering institution, or equivalent are essential. Industrial instrumentation experience is required together with the ability to lead and co-ordinate the activities of technicians and mechanics. Physics, radar or light electrical background may be an advantage. Where necessary, training in nuclear aspects of the work will be given.

Salary between
£845 (at age 25) and £1,315

Contributory Superannuation.
Staff housing scheme.

Send postcard for application form, quoting reference 2977/J28 to:—

Works Secretary,
UNITED KINGDOM
ATOMIC ENERGY AUTHORITY,
INDUSTRIAL GROUP,
Chapelcross Works, Annan,
Dumfriesshire, Scotland.

Closing date: May 4, 1959.

GENERAL ELECTRICITY GENERATING BOARD

NUCLEONIC INSTRUMENTATION AND REACTOR CONTROL RESEARCH LABORATORIES, LEATHERHEAD, SURREY

Applications are invited for the following appointments:

ELECTRONIC ENGINEERS to form a group that will be employed on the laboratory test and assessment of the performance and reliability of nucleonic and other reactor control instruments which will be used in the nuclear generating stations.

A Group Leader and two assistant Engineers are required and candidates should have a degree or equivalent qualification. Experience in the design and testing of nucleonic instruments, servo or control systems is essential.

Salaries for the above appointments; according to duties and responsibilities.

Group Leaders—On a scale within the range £1,530—£1,980 p.a.

Assistant Engineers—On a scale within the range £1,195—£1,775 p.a.

Application Forms obtainable from the Personnel Officer, 24-30 Holborn, London, EC1, should be completed and returned by April 24th. Please mark envelopes "Confidential Ref. NP/93."

EDUCATIONAL

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY
(UNIVERSITY OF LONDON)
POSTGRADUATE COURSE IN NUCLEAR POWER

A full-time postgraduate course in nuclear power is held each year at Imperial College. This course is conducted from the engineering point of view and is intended primarily for graduate engineers and applied scientists who wish to pursue a career in the design, development and construction of nuclear power stations. A special feature of the course is the inclusion of a design study of a complete nuclear power project. Experimental work will include the use of a natural uranium-graphite exponential assembly.

Further information may be obtained on application to the
REGISTRAR, IMPERIAL COLLEGE, LONDON, SW7

CAPACITY AVAILABLE

ALPHAMIN LIMITED.—A complete design and fabrication service available for all types of aluminium and steel fabrication including welding by Argon-arc process. We have considerable design experience and would welcome your enquiries. 4 Dunston Street, Kingsland Road, London, E.8. Phone CLIssold 4161.

FOR SALE

LIBRARIANS!

Complete set of Russian journal of nuclear energy, *Atomnaya Energia* for sale. Box NP 203, Nuclear Power.

Telephone your classified advertisement to **MUSEUM 8252**

GAMMA RADIOGRAPHY OF PIPELINES GAMMA AND X-RADIOGRAPHY OF TANKS AND PRESSURE VESSELS
Weld examination to Lloyds, etc. Quick, efficient services available for work on site now.

GAMMAX (LONDON) LTD.,
Cecil House, Wharfdale Road, London, N.1
Telephone: TERminus 0677 and 6925

R. & J. PARK LTD
Dominion Works, Chiswick
England

Export packers, shippers and forwarding agents. Specialists in packing heavy machinery.

ROSSER & RUSSELL LTD
Queen's Wharf · Hammersmith
London · W.6
Telephone: RIVerside 4161

GENERAL ENGINEERS AND MANUFACTURERS OF SPECIAL MACHINERY TO CUSTOMERS' DESIGN

JAMES BRUTON & SONS Ltd

MANUFACTURERS OF VITREOUS ENAMELLED IRON SIGNS & PLATES For all Purposes
87-89 Hedge Lane, PALmers Green
Palmers Green, London, N.13 6845 (2 lines)
Telegrams: " Enambrut, Norphone "

METAL SPINNING
PRECISION METAL SPINNING
Top Grade Work and Results
First Class Service from
Glanville Metal Spinning Co Ltd
31a Wicklow Street, London, WC1
Phone: TERminus 1829

Chartered Patent Agents
W. H. BECK, GREENER & Co
7 Stone Buildings,
Lincoln's Inn,
London, WC2

CHAncery 2535

Electrical windings on production basis, F.H.P. armatures, stators, transformers, resistance tubes, Solenoid coils, chokes, etc.
Immediate attention to all enquiries
KENSAL ELECTRICS LTD
151 Kensal Road, London, W10
LAD 4530

BARREL FINISHING
CUTS PRODUCTION COSTS!!!
Use barrel finishing methods and save 60/90%
GRANATT
CHEMICAL & ENGINEERING Co
Austin Rd, Battersea, London, SW11
Tel: MACaulay 7723/1343

WE MAKE TANKS, FRAMES, DUCTS, INSTRUMENT PANELS & CHIMNEYS
Let us have your enquiries for welded fabrications large or small. And we can press 200 Tons, guillotine ¼ in. plate, bend and cylindrical roll.
SHELMERDINE & MULLEY LTD.,
Edgware Road, Cricklewood, N.W.2
GLAdstone 7677-8

LYNCH & BAKER LTD
Architectural Engineering — Industrial Experimental
MODEL SERVICE
3 Mark Road, Hemel Hempstead, Herts — **Boxmoor 4788**

R. C. CUTTING & CO LTD
Leading Specialists in LIGHTNING PROTECTION
Sub-contractors for Bradwell Nuclear Power Station
Branches: Birmingham, Bristol, Manchester,
Head Office: Sheffield
L.P. Dept.,
17 Crawford Street, London, W.1 — **HUNter 0435 (2 lines)**

C. W. GARRETT & SON
for
ALL DRAWING OFFICE SERVICES, PROCESSES, MATERIALS AND EQUIPMENT
WINDMILL ROAD, BRENTFORD MIDDLESEX
Telephone : ISLeworth 4433 (4 lines)

SPECIAL
CLASSIFIED
FEATURE

AT
YOUR
SERVICE

SECURITY PRODUCTS MANUFACTURING CO LTD
For all Security matters our FREE SECURITY ADVISORY SERVICE is at your disposal
44 Tottenham Court Road, London, W.1 — **LANgham 4746 (3 lines)**

TRANSLATION WANTED?
Call SLOane 7059 4151
POLYGLOT TRANSLATION SERVICE LTD
283/4 Terminal House, Victoria, London, SW1
Specialists in Technical Specifications

THERE IS NO FINER INDUSTRIAL FLOORING THAN SURFEX
Trowel laid on ANY FIRM SURFACE, SURFEX lasts a lifetime, is seamless, waterproof, will not crack. Also POLYFLEX for offices, canteens, etc., cheaper than linoleum! Write to-day for free literature to:-
Dept. C.I., SURFEX FLOORING CO., LTD., Station Approach, CAMBERLEY, SURREY Tel: Camberley 2263

DESIGN TEAMS
available for plant and mechanical engineering projects in the nuclear field
NORRIS BROTHERS LTD
53 Victoria Street, London, SW1
Telephone : ABBey 6132

FIRE
Extinguisher Hire, Maintenance and Renovation Service
READ & CAMPBELL LTD
Fire Protection Engineers Est. 1878
Head Office:
75 Victoria Street, London, SW1
Tel: ABBey 2602 & 5762

'TANALITH'
COOLING TOWER TIMBER PRESERVATION
Hickson's Timber Impregnation Co (GB) LTD
Castleford, Yorkshire
Tel: Castleford 2607

EDWIN LEWZEY & CO
32 Gloucester Road, Teddington Middlesex
INDUSTRIAL PHOTOGRAPHERS TO TRADE AND INDUSTRY
Giant enlargements in a few hours Nation-wide service
Telephone: MOLesey 4471

ELECTRICAL WATER CONDITIONING AND SCALE PREVENTION Service to Industry
R.D.E. LTD
26a Chequer Street, St. Albans, Herts
ST. ALBANS 53371

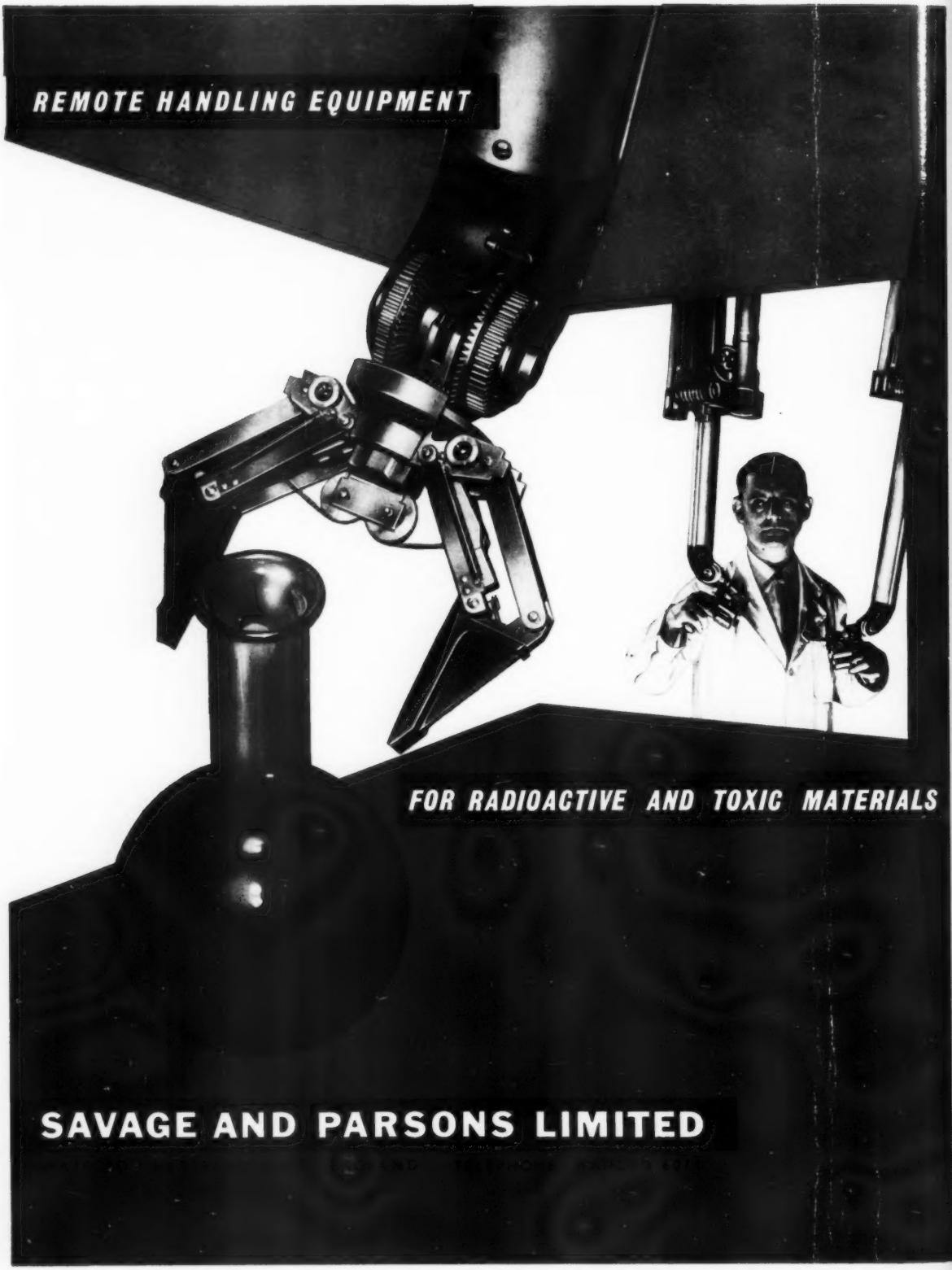
MANCUNA ENGINEERING LTD
DENTON, MANCHESTER
SPECIALISTS IN GAS CLEANING AND GAS TECHNOLOGY
District Office:
59 Victoria Road, Surbiton, Surrey
Tel: ELMbridge 9793

W. & E. MOORE LTD
13/31 Poplar High St, London, E14
Telephones: EASt 2613-6 & 4601-2
Lifting Equipment Specialists
CRANES, HOISTS, LIFTS, Etc.
Inspection, Testing, Repair and Maintenance

EXPERT HEAT TREATMENTS LTD
FULL SCIENTIFIC HEAT TREATMENT of all Metals
Case Hardening up to 10 ft
Garth Road, Lower Morden, Surrey — **DERwent 7744 (4 lines)**

'Pyrolith'
FLAMEPROOFING of timber, hardboard, plywood, insulation board by vacuum pressure impregnation
Hickson's Timber Impregnation Co (GB) Ltd
Castleford, Yorkshire
Tel: Castleford 2607

Tick **No 207** on reply card for further details



XENOZOIC TALES